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# CHEMICAL & METALLURGICAL ENGINEERING

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### Ourselves

FOUR times within the history of this journal we have injected a personal note into the editorial columns. The first occasion was when we introduced ourselves, nearly sixteen years ago. Twice after that we explained the successive changes in name which the journal underwent, and finally in 1912 we celebrated the tenth anniversary "of an insurgent engineering journal." Looking back over the record as it has been written in eighteen volumes, we may be pardoned if we indulge just a moment's gratification over the unflinching approval which our readers have so freely and genuinely extended as we have developed in the passing years. Truly, our readers have made possible by their splendid support whatever of achievement may be recorded in our volumes.

From the beginning this journal had a field that was not covered by any other similar publication. Unhampered by precedent and encouraged by a wonderfully friendly reception, we found it comparatively easy and delightful to break new trails. Always we have kept in mind the needs of the industry which we served, and whenever expansion or change seemed appropriate in the interest of better service we have never hesitated to make the effort to meet the need. Successful technical journalism requires a recognition of industrial trend and adaptability to changing conditions. Given these elements internally and the support of the profession from the outside and the result is inevitable. It must now be quite evident to any observer of current industrial development what we foresaw several years ago, namely, that chemical engineering is playing the dominant rôle of the day. Our country stands on the threshold of a marvelous development which has its basis in applied chemistry. There is scarcely an industry of any magnitude or importance that is without its chemical phase, and we are but beginning to appreciate the value of chemical control. Due to the stimulus of war we have suddenly become a chemical nation, investing millions in chemical manufacturing both on government and private account, and staking the future industrial independence of the country on the chemist and engineer.

It is under these favorable auspices, which we anticipated when we began semi-monthly publication several years ago, that CHEMICAL AND METALLURGICAL ENGINEERING now greets old friends with a revised and more appropriate name. There is fitness and proportion in all things—even names—notwithstanding the implication to the contrary in the classic query of the poet. Today's name would not have fitted the pioneer days of electrochemistry when this journal was launched, nor would *Electrochemical Industry* fitly indicate the broad field of



chemistry applied to industry and ore treatment which characterizes our field today. Further, as the metallurgist's art has progressed from rule-of-thumb to scientific standards, chemistry has been the underlying factor in the change. Metallurgy, therefore, has become a great branch of chemistry applied to the treatment of ores and metals—one great phase of our chemical industry. And so, with confidence in the logical nature of the change we have made, and feeling assured of the approval of our friends in this step in the evolution of a live, independent exponent of the chemical and metallurgical industries, we enter upon a new volume with a new sense of responsibility. Our house is now in order. We espouse the cause of the chemical engineer, the metallurgical engineer, and of those close relatives, not hyphenated, who are differentiated by the prefix "electro." We abandon no phase of the industry that has been included in our past evolution. There will be no diminution in our attention to electrochemistry and electrometallurgy. The treatment of ferrous, non-ferrous, precious and base metals and ores will have our interest as in the past, and the rapidly expanding chemical industry will be fitly served as becomes so important a factor in our national life.

### Speaking of Lead, Who Pays the Freight?

FIFTY years ago lead was cheap because it came from easily worked bonanza deposits. Since then the upward tendency due to the steady decline in grade of ore and increase in cost of labor has been counterbalanced by improvements in mining and metallurgical methods, together with decrease in freight rates. Indeed, the last item, freight, is so important to Middle Western and Western producers that it would be profitable to consider the effect of Mr. McAdoo's recent revision of rates. The increase amounts to 25 per cent on most commodities, ranging upward on essentials like coal, coke, flux and ore to a probable maximum of 55 per cent on bullion. With such unexpected jumps in the price of transportation, the custom smelter who contracted several years ago to treat ore at a price based on current and expected costs at that date is left with the alternatives of negotiating for a revision of the payment schedule, shutting down, or tumbling into bankruptcy.

The purely custom smelter or refinery operates under entirely different conditions from one which treats its own ores. The latter's deficit on a rising market may easily be swallowed by the handsome profit of the producing and selling departments. The custom smelter, on the other hand, is something like a salaried man if it operates on a "cost plus" schedule; in effect it then works for the miner, being but one of a train of related industries necessary to take lead from underground and put it into the plumber's pot. The total cost of the train must not only be less than the selling price of the metal, but the miner must get a share sufficient to pay for the delivery of the ore to the smelter, who in turn must receive a portion necessary to load the pig on cars. Lastly, the refiner's income at the least must balance his cost of putting usable metal on the market.

The production of lead is a field particularly well suited to study the effects of inflated prices. For years the price has fluctuated within such narrow limits that mutual relations between the various parties to the pro-

duction were well stabilized, and it had become almost a common saw that "Four cents is a good price for lead." On this basis the average of 4.3 cents for the decade ending with the war evidently provided a comfortable, perhaps more than comfortable, share for miner, smelter and refiner, with somewhat the following partition:

|          | Cents |
|----------|-------|
| Mining   | 1.4   |
| Smelting | 1.8   |
| Refining | 1.1   |
| Total    | 4.3   |

It will be noted in passing that these approximately correct figures correspond to conditions in those regions feeding the Colorado and Utah smelting centers. Most of these ores, of course, carry other valuable metals than lead, but the entire cost of smelting is assessed against the average lead content. This gives a fictitiously low return to the miner for his lead, but his receipts are augmented by the values of gold, silver, copper and iron. The case has thus been simplified for the argument which follows, since the wartime appreciation in market value of silver and copper has been equal to or greater than that of lead. "Mining" is thought of as including mining, development, amortization, freight and all other expenses incidental to delivering the ore to the smelter. "Smelting" includes the entire cost of recovering the base bullion, while the item "refining" covers freight on bullion and selling costs as well.

Since the war the price of everything has soared. In an inquiry in the Salt Lake region it was found that labor is receiving 50 per cent more now, for a considerably less efficient performance. Supplies have increased 35 per cent, coal 30 per cent and coke 50 per cent. On this basis the statement freely repeated that production costs have increased two-thirds in the last four years appears somewhat exaggerated when applied to the lead-smelting region; possibly an average increase of 50 per cent would represent the costs ruling for the first half of 1918. Therefore, in order that the operations may now proceed as comfortably as before, the new apportionment would approximate

|          | Cents |
|----------|-------|
| Mining   | 2.1   |
| Smelting | 2.7   |
| Refining | 1.6   |
| Total    | 6.4   |

The market was about 6.8 cents during this time, the surplus 0.4 cents going generally to the miner, who thus seems to be better taken care of than his partners. Indeed, it is unquestionable that the two latter have not increased their income proportionately to their costs, since so many old contracts are still in effect. In other words, the adjustment of contracts will lag far behind, while the ore shipments closely hug the rising markets.

But assuming for the instant that each has revenue enough to enable him to carry on his share of the work, now comes an increase in freight rates, bad enough in itself, but scaling all prices upward to an even greater extent. Carriage on bullion alone is increased 0.3 cents per pound. The smelter is hard hit on account of its



large requirements of flux, coal and coke. The miner weeps over his ore freights. An estimated reapportionment of expense would now be

|         | Cents |             |
|---------|-------|-------------|
| Miner   | 2.1   | + 0.2 = 2.3 |
| Smelter | 2.7   | + 0.3 = 3.0 |
| Refiner | 1.6   | + 0.4 = 2.0 |
|         | —     |             |
| Total   |       | 7.3         |

It is only another instance of the unending cycle: Up go wages, up go butter and eggs. Up go butter and eggs, up go wages. This much is plain, however: producing lead on a 7-cent market in 1918 is not as good a business proposition as on a 4-cent market in 1914. And when the price of lead exceeds the cost of production, as it will sooner or later by the operation of natural laws or by governmental price-fixing, the three partners in the business of producing lead must mutually revise their agreements so that each can continue to perform his indispensable functions. The mining company, for instance, can easily see the folly of insisting upon the continuance of a contract which will shut down the smelter, for he evidently could find no other present outlet for his ore on the old basis. On the other hand, a smelter with a sliding-scale contract which pinches the small producer should not strangle this output, even if small. Fair-minded men realize that the violent fluctuation of supposedly stabilized transportation is one of the things beyond control which invalidate price agreements; patriots subscribe to the motto, "Produce more, consume less"; and common sense indicates that galena is no good for making shrapnel bullets.

#### On the Price of Gold and Other Things

THE gold producer is between the devil of leaner ore and the deep blue sea of fatter commodity and labor prices. The before mentioned devil has kept the world's gold output practically stationary for the last ten years, and strenuous efforts to lower extraction costs by improved mining and metallurgical management have been overwhelmed by a tidal-wave of war prices.

Suppose you had revised your boiler room practice and equipment with much care and had finally increased the overall efficiency by some fifteen per cent. After looking over the results with considerable complacency you receive a letter one morning from your coal contractor saying that thereafter the price of your fuel will be the \$2.50 allowed by administrative action instead of the \$1.00 called for by your contract. Then you would feel as the gold miner feels.

The copper producer is in a different boat. He had cannily taken advantage of the present style in price-fixing and can point out that the increased cost of living demands a higher wage. For be it understood that the law (if it be a law) of supply and demand is distinctly out of date; Mother Grundy has whispered that a ruffian called Mars has spiked its guns, so that the time-honored statute can be winked at with impunity.

Time was when the impression was abroad that the more a man produced the better he should be paid, that the more efficiently a business was conducted the better should be the profits. Maximum production with the minimum expenditure seemed the ideal which would

provide amply for the comfort of great and small. But apparently we were all wrong—now-a-days wages are fixed by the cost of living, men and industries are paid according to what they spend, the tradesmen get all they can and let the hindmost look out for himself. Truly a comfortable creed if you are some distance from the hindmost, but a rule of conduct not calculated to cause soul-searching as to whether one is doing the best that is in him, or getting the best out of his tools.

Fortunately, there is a tacit agreement that this new philosophy is spurious and results in a vicious cycle of increasing prices, for all of us, through our government, have agreed to tax the war excess profits, proceeding on the theory that no one should grow fat on blood money. Right here is where the gold miner feels aggrieved. Theoretically, war taxes are imposts on excessive income returned from the inflated prices attending this cataclysm. Everyone can and does charge more for his produce than he could before, *except* the gold miner. The price of his yellow metal was established internationally long before the present price-fixing program was imagined; but unfortunately the more fundamental relationship between an ounce of gold and a day of labor was not recognized. Consequently the price of gold actually has dropped through its inability to purchase the old amount of other necessary products of man's labor. Since war prices have brought only a decrease in net revenue to the gold miner, his claim for exemption from war-profit taxation is well founded. It will probably fall on deaf ears, however, since to the ordinary run of mankind mining is a speculative enterprise rather than a foundation stone of industry.

The ultimate relationship of the value of gold and of all other things is somewhat as follows: If a country needs a thing, such as it does gold, and needs it badly, its citizens set themselves about getting it. If it exists, it can be had for a price. But the price paid to get it must not be greater than that which it in turn will buy. Therefore, as long as gold is to be the monetary standard, its value must fix the maximum limit to the price of labor and commodities. The spectacle of a stagnating gold production, while painful to the gold miner, is a welcome indication that, taken in a large way, the crest of high prices has been reached; a halt must be called else passing time will dangerously inflate an already top-heavy financial structure.

#### Devil-Hounds and Hounding the Devil

EVERY red-blooded unhyphenated American must have rejoiced recently at the published accounts of the performance of our marines when put to the supreme test in battle. Widely advertised in recruiting campaigns as "the first to fight," they ran true to form and showed that they were the last in the fight as well. Report has it that the enemy characterized them as *teufelhunde* after his first contact with them, but we rather incline to the artist's idea as expressed in the colored supplement to this issue, and agree with him that our marines are engaged in the laudable pursuit of hounding the devil. We suggest to our readers and subscribers that this supplement may be made to serve a useful and patriotic purpose if posted in the office or plant where the artist's inspiration may be transmitted to all.



## Meeting of the American Institute of Chemical Engineers

Important War-Time Convention Well Attended by Members from Distant States—  
Exceptional Opportunities Afforded to Visit Pulp, Paper and  
Chemical Plants of the Brown Company

THE tenth semi-annual meeting of the American Institute of Chemical Engineers was held June 19-22 at Gorham, N. H., which is the nearest village to the summit of Mount Washington—16 miles by carriage and automobile road. Gorham is surrounded by high mountains, there being twelve peaks within an eight-mile radius, the average height of which is more than 5000 feet. Mount Adams, as seen from Gorham, is the highest rise of land of its kind east

above which it towers to the height of 4937 feet; while Mount Washington rises but 4722 ft. above Fabyans and Bretton Woods, and 4661 feet above the Glen."

### WELCOMED TO NEW HAMPSHIRE

On the arrival of the Institute Wednesday forenoon MAYOR GEO. F. RICH met the organization at the Berlin City Hall and turned over the keys of the City. MR. JOHN HULAN spoke eloquently in appreciation of the



1. Wallace Savage  
2. W. C. Graham  
3. E. H. Leach  
4. Richard K. Meade  
5. P. D. Bray  
6. F. E. Lodge

7. D. O. Chute  
8. Louis A. Olney  
9. George Oenslager  
10. Ralph H. McKee  
11. W. H. Swarman  
12. Henry G. Sommer

13. J. L. Schuler  
14. Hugh Keiser Moore  
15. S. Felton Grove  
16. William F. Zimmerli  
17. Stephen L. Tyler  
18. T. R. Wagner

19. J. C. Olsen, Secretary  
20. W. P. Mason  
21. L. D. Vorce  
22. A. C. Langmuir  
23. W. B. Campbell  
24. E. C. Holton

of the Mississippi river. Sweetsir's Guide Book says: "Mount Adams, as seen from a point on the road about one and one-half miles beyond the village, is the highest elevation which we can look at in New England from any point within a few miles of the base. Indeed, it is the highest point of land overlooking a station near the base that can be seen east of the Mississippi. The peak of Mount Adams (5805 ft. high) is about seven miles from the point before mentioned (868 ft. high).

honor of entertaining such a distinguished organization and informed the members that the Chamber of Commerce had arranged with citizens to furnish sufficient automobiles to carry the Institute to and fro. MR. O. B. BROWN spoke at the Grotto after lunch, where he told of the transition of the saw mill, starting in 1846 with the enormous mill-waste fires, through a period of forty-five years, when the sulphite wood pulp process was finally developed about 1888. Many ingenious ways of



Power Plant

Cell House

Bleach House

Chemical Plants

ELECTROLYTIC AND CHEMICAL PLANTS OF THE BROWN CO.

getting laths, shingles, etc., from normally unfit slabs were developed by saw-mill engineers, but nevertheless thousands of dollars worth of material was wasted weekly. In Michigan the mill people turned to chemistry and put up brine evaporators and Saginaw became the Salt City. The pulp process was the contribution of the chemist in the spruce belt, by which not only the waste was conserved, but thousand of square miles of small timber, practically valueless as it stood on the cut-over hills, was soon made a precious harvest crop. MR. BROWN did not speak at length, but his actions during

ladies saw this famous section of New England better than the chauffeured tourist ever did.

#### THE BROWN MILLS, BERLIN, N. H.

The Institute chose Gorham, so famous as a resort of the White Mountains, not merely because it offered its members a pleasant vacation from industrial pursuits, where they could discuss papers and become better acquainted through personal contact, but because from precedence as much as anything else, and certainly not from a lack of appreciation for the aesthetic; it has been



23. John Morris Weiss  
24. Chas. S. Hollander  
25. Ray Potter Perry  
26. Paul I. Merrill  
27. W. C. Bainbridge  
28. Luis E. Eckelmann

29. A. L. Gardner  
30. Colby Dill  
31. Robert D. Bonney  
32. Percy C. Kingsbury  
33. Philip S. Barnes  
34. Jules Behie

35. H. Gesell  
36. W. O. Quayle  
37. A. E. Nash  
38. J. H. Clewell  
39. David Wesson  
40. Fred A. Whitaker

41. James P. V. Fagan  
42. Geo. A. Prochazka  
43. T. P. Summers  
44. William Garrigue  
45. H. G. Spear  
46. C. Bal Lilhne

the visit of the Institute expressed better than word the cordiality of his welcome.

#### LADIES WELL ENTERTAINED

The automobile service was the greatest treat in filling the program for ladies. The scenery of the White Mountains is an attraction that all ambitious travelers crave, and under the leadership of MRS. O. B. BROWN, MRS. HUGH K. MOORE and a dozen others the visiting

customary to hold these meetings at such points as offered visiting privileges to highly important chemical manufacturing plants. Fortunately, MR. HUGH K. MOORE, through his connections with The Brown Company, secured permission for his fellow members to visit their enormous lumber, pulp, paper, oil and chemical factories, which form the economic foundation of the thriving city of Berlin, but a few minutes ride by auto or trolley from Gorham.



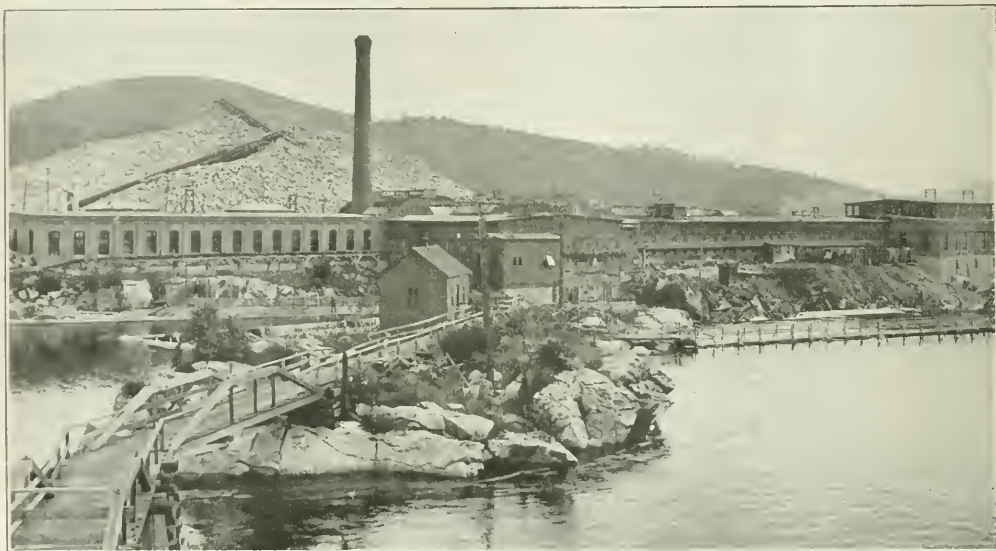
### SULPHITE PULP MILLS

By the time one approaches these large mills, the sense of proportioning mass has been greatly augmented by the mountain scenery so that the 100,000-cord mountain-like wood pile at the supply yard does not excite even as much surprise as the ancient wooden horse of Troy. Nevertheless, the enormous wood-barking drums, the gang saws, the chippers and sorters, the extensive and various conveying appliances which deliver the wooden chips into any one of the long rows of digesters, the appliances for chemically controlling operations, and finally the sulphur burners and the acid ab-

sorption towers, bring emphasis to the statement that besides being the largest sulphite pulp mill in the world, this is certainly one of the greatest consumers of the products of nature. The magnitude of the operations may be summarized in the fact that if the daily wood supply of these mills were piled four feet high and four feet wide, it would extend over two miles in length.

solution is produced, which is concentrated, desalted and dehydrated to 76 per cent  $\text{Na}_2\text{O}$ , which is then put in the usual form of drum for shipment. Bearing in mind that the policy of this company is to utilize all by-products, one is not at all surprised to find a little brick furnace, heated to incandescence, up on the cell-house roof, which is believed to be the first commercial furnace burning hydrogen in chlorine gas as well as the only known hydrochloric acid plant that works without any attendants.

Having quantities of sulphur on hand for use in the sulphite mill, it was no more than natural that the sul-



RIVERSIDE MILL AND WOOD YARD OF THE BROWN CO.

phur chlorides should be made by burning sulphur with chlorine, also that wood charcoal and sulphur should be combined to carbon disulphide, and that from the above carbon tetrachloride and chloroform should follow in sequence. Medicinal chloroform is also made by the alcohol-bleaching powder method in tank-car quantities at the present time.

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### THE CASCADE PAPER MILL

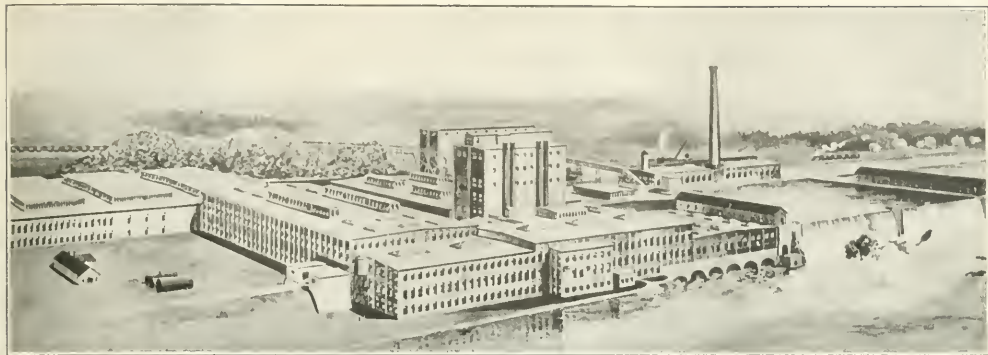
Not all of the pulp is sold as such by the company, the Cascade Mill shipping about 200 tons of paper daily. In the operation of this plant there are employed 800 persons receiving about \$11,000 per week; 23,000 horsepower is generated, of which about 8000 is electric and 7000 each hydraulic and steam; seventeen 400-hp. boilers burn 125 tons of coal daily in furnishing steam. Four immense paper machines each produce 48 tons of news paper daily, which is 164 inches wide and runs through the machine at the rate of 600 ft. per minute.

### THE CHEMICAL DEPARTMENT

Years ago the company bought its bleaching powder from England, but for some time has operated its own electrolytic cells of a design by MESSRS. MOORE and ALLEN. An extremely chlorate-free sodium hydroxide

### THE OIL-HYDROGENATION DEPARTMENT

DR. CARLETON ELLIS has written a book on this subject so that the interested reader may find elaborate published accounts of how oils in the presence of nickel will absorb hydrogen gas and change their properties by becoming solids at ordinary temperatures. Pure peanut oil is used in the Brown plant. The features of the process are the thorough manner in which the reagents are brought into contact, the moderate temperatures and the reaction speed, so that the fat is soon on the chill rolls, then into the "Kream Krisp" container. The art of the oil refiner is to purify this carbon-hydrogen-oxygen compound—oil—furnished us by nature. With the exception of adding hydrogen to the product as in the above process, all oil refining consists of removing foreign products by washing out fatty acids, etc., with dilute alkali, removing soaps, colors, etc., with fuller's



CASCADE PAPER MILLS OF THE BROWN CO.

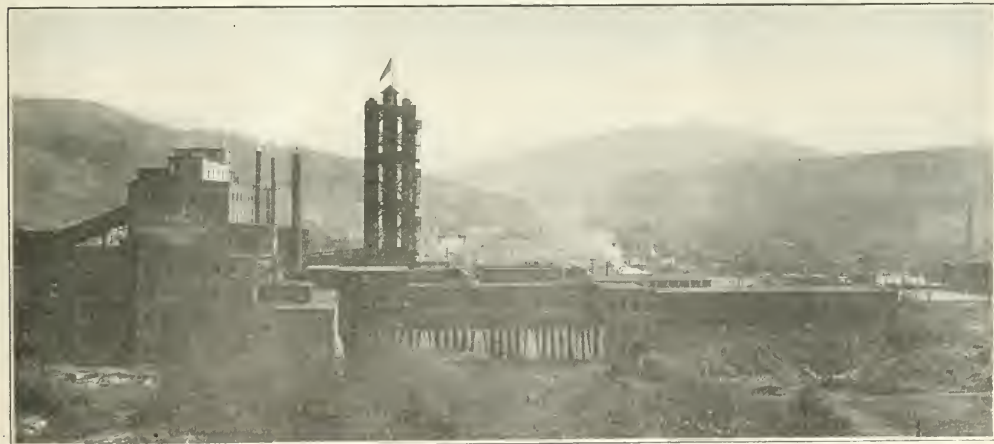
earth, and steam-distilling all odorous volatile oils and moisture from the finished product.

#### PHOTOGRAPHIC DEPARTMENT

Of the many technical laboratories special mention should be made of the photographic department. MR. JOHN H. GRAFF has developed many applications of color photography in technical analysis of pulp from various woods. Very beautiful artistic pictures of chocolate coatings, etc., were shown which approached the actual color and texture of the original specimens. There is promise that the physical qualities of oils and fats will eventually be studied by this method similar

Fine club houses for young women and men have been erected; but more unusual and greater than all is the "Show," which stimulates good fellowship better than any other activity and provides mental training for scores of participants.

The members of the Institute agreed that they had never witnessed better amateur talent than by the Burgess Minstrels in the presentation of "A Joyous Jumble of Junk" in three acts entitled "Somewhere in America." MR. HERBERT SPEAR proved to be as much at home leading a company of ninety as though he were by profession a "Comical Engineer" instead of chemical. DENNIS CAMPBELL and LORA ROWELL presented the rural



BURGESS SULPHITE PULP MILL OF THE BROWN CO.

to those of steel and alloys in metallography. Mr. Graff has a blue center on a red field through which he filters the microscope light, so that the finest differentiation between the planes of cleavage, faces, etc., is obtained in the photograph. His photos of jewels, such as diamonds, are the best means known today for recording the true color effects as well as physical forms and thus give positive identification records.

The social welfare of the workers in the Brown Company has not been provided for on the seventh day alone.

act in refreshing manner. The "Six Smiling Scoundrels" were as capable as if they had seen service with Lew Dockstader himself. Of their acts, the kiddy kar worked extremely well and would take New York almost as well as the Daffodils did under the lead of Bessie McCoy. Of their riddles; the "Resemblance of a Slacker to a Lemon Pie" may be taken as an average. Some good ones were perpetrated on a few individual members of the Institute, but the "No Crust on Top and Yellow Inside" was left for each individual himself to

determine how far he had a right to stray from the kahki. DR. WESSON said that there was less than a third as much  $\text{CO}_2$  in the air at Berlin as in New York or Boston, which must account for the extra brilliance of the young ladies in the cast.

#### BANQUET AT THE MT. MADISON HOUSE

One hundred and four covers were laid at the tables which were set in the form of a large U. DR. MASON acted as toastmaster. MR. W. R. BROWN, who has

been built to regulate the current, etc., yet he did promise to furnish all those who came up into the woods a regular Brown welcome. DR. OLSEN gave the toast to the ladies, which was delivered in a manner typical of the genial Secretary of the Institute.

#### TRIP THROUGH THE MAINE WOODS

A heavy rain began Friday night which continued all day Saturday, but after voting on whether it was advisable to make the scheduled trip up through Thir-



OIL REFINERY AND HYDROGENATION PLANT OF THE BROWN CO.

charge of the timber operations of the company, made an address, and while he did not mention the fact that his department is really the largest manufacturing department of the whole company, where cellulose is manufactured by catalytic action of sunlight on  $\text{CO}_2$  in the leaf cells, where the water vapor from the Atlantic ocean is condensed on the mountain sides to keep the Androscogin flowing, and where storage reservoirs have

teen-mile woods to Errol Dam, so many members decided to go that the official meeting was transferred to the Lakewood Camps in spite of the weather.

Fourteen papers were read during the meeting, occupying ten hours time. Some of these will be printed in full or in abstract form in future issues of CHEMICAL AND METALLURGICAL ENGINEERING. Every minute of the trip was time enjoyably spent.

#### Government Restricts Location of New Industries

A policy has been adopted and made effective for preventing further increase in the volume of war orders and the number of establishments handling them in the area known as the congested manufacturing and transportation district. This district comprises the New England states; eastern and southern New York; Pennsylvania as far west as Williamsport and Altoona; all of New Jersey and Delaware; eastern Maryland, not including Baltimore.

Exceptions to this policy will be made only if unavoidable through inability otherwise to provide for war needs.

The congested district comprises those eastern states in which so large a proportion of war industries is located as to make it difficult to supply all with necessary raw material and fuel. This difficulty obtains because coal for those industries is

mined in the territory west of the Allegheny Mountains. It must be carried into this congested district by a limited number of railway lines and by ships from Hampton Roads and Baltimore.

The amount of coal, therefore, which can be transported into this congested area during any one season is limited, and is an entirely separate problem from the production of coal. However much coal is mined in western Pennsylvania, West Virginia and Ohio, only so much is available for this congested district as the railroads and ships can transport.

A careful analysis of the possible coal movement shows that the increased industrial activity in those eastern states has created a requirement for coal which exceeds the limit of possible transportation of coal, plus necessary materials for manufacture. A map of the congested and restricted district has been issued to all Government departments.



## James Douglas

**D**R. JAMES DOUGLAS, philanthropist, mining engineer, chairman of the board of directors of the Phelps, Dodge Corporation, died at his home in Spuyten Duyvil, near New York City, on June 25 in the eighty-first year of his age. He had been president of the corporation for many years until recently, when he resigned on account of failing health.

Dr. Douglas gave away large sums of money for educational and charitable purposes, but his most noteworthy gift was made to the General Memorial Hospital of New York of 3.75 grams of radium, value \$375,000, to be used in cancer-therapy. This radium represented one-half of the output of the National Radium Institute produced by three years of work on carnotite ores in the West. Dr. Douglas was born at Quebec, Canada, Nov. 4, 1837. His father, Dr. James Douglas, Sr., was a surgeon of repute, and the first to introduce modern treatment of insanity into Lower Canada, as the founder of the Quebec Lunatic Asylum, in the management of which for some time his son James participated. James Douglas was educated in Canada, Germany and Scotland. He received the degree of A. B. at Queens University, Canada, studied medicine at Laval University and was professor of chemistry at Morrin College, Quebec. He acquired his first experience in mining and metallurgy through his connection with the Harvey Hill mines and other mining properties in Lower Canada and went to Phoenixville, Pa., in 1875, where he took charge of the metallurgical operations of the Chemical Copper Co., where he was first to refine on a commercial scale pure copper by the electrolytic method.

In 1880 Dr. Douglas first visited Arizona and saw the Copper Queen mine, and a year later, in the interest of the late William E. Dodge and the late D. Willis James of the old firm of Phelps, Dodge & Co., acquired copper claims in the Warren mining district, Arizona, and the copper mines at Morenci, Ariz. These claims in

1885 had become productive, and were absorbed into the Copper Queen Consolidated Mining Company, of which Dr. Douglas became president.

Later, the Detroit Copper Mining Co., Morenci, Ariz.; the Untied Globe mines, Globe, Ariz.; the Motezuma Copper Company, Nacozari, Sonora, Mexico; the Commercial Mining Co., Prescott, Ariz.; the Stag Cañon Fuel Company, Dawson, N. M.; and the Burro Mountain Copper Company, Tyrone, N. M., were acquired by companies of which Dr. Douglas was president and manager. In 1908 these properties were consolidated into the fifty million dollar corporation of Phelps, Dodge & Co., of which Dr. Douglas was president. The railroad building under Dr. Douglas's management, begun in the early eighties, continued to expand with the growth of the copper companies, and at the present time under the title of the El Paso & Southwestern Railroad Company, operates over one thousand miles of standard-gauge road.

Dr. Douglas was the author of a number of books, among which were "Canadian Independence," "Quebec in the Seventeenth Century," "New England and New France," "Journals and Reminiscences of James Douglas, Sr." He also wrote very many literary and technical articles, reports, addresses, and delivered many lectures, including a series of the Cantor lectures, before the Society of Arts, of London.



JAMES DOUGLAS

Dr. Douglas was twice president of the American Institute of Mining Engineers, was the recipient of the gold medal of the Institution of Mining and Metallurgy of London and in 1915 was awarded the John Fritz medal. In 1899 McGill University conferred on him the honorary degree of LL.D. In 1916 he was elected Chancellor of Queens University, his alma mater.

In 1860 Dr. Douglas married Miss Naomi Douglas, daughter of Capt. Walter Douglas, of Quebec; six children were born, of whom the following are now living: Major James S. Douglas, Watler Douglas, Miss Elizabeth Douglas and Mrs. Edith M. Douglas.

## Camphor Production and Imports

The supply of camphor will be governed by the ship cargo space available from Japan and necessary munition requirements. It is hoped that the short markets will stimulate synthetic investigations, as well as the development of this gum tree in the Americas. As is well known, pinene, the light distillate from turpentine, saturated with anhydrous hydrochloric acid gas at a low temperature, gives a solid gum product. This has been trade named artificial camphor and scientifically called pinene hydrochloride, both of which names are not well founded, the product having proven to be a camphene-chloride. As natural camphor is a ketone, the chlorine is

substituted with an hydroxyl radical, the product oxidized, and actual artificial camphor produced. Perhaps hydrofluoric acid would be better than hydrochloric, the fluorine being better removed by silica compounds and the entire reactions becoming more co-ordinated and complete.

The following are the camphor imports for March periods:

|           |               |
|-----------|---------------|
| 1918..... | 3,736,240 lb. |
| 1917..... | 7,099,423 lb. |
| 1916..... | 4,122,735 lb. |

## Our Expanding Dyestuff Industry

U. S. Tariff Commission Makes Preliminary Report on Census of Coal-Tar Products for 1917—Shows Production Exceeds Pre-War Imports—Value of Exports Exceeds Pre-War Imports

THE United States Tariff Commission announces the completion of its census of coal-tar products for 1917. This group of products includes not only the coal-tar dyes and the crude and intermediate materials required for their manufacture, but also all of the medicinal and photographic chemicals, explosives, synthetic resins, synthetic perfume materials, and flavors which are in any way derived from coal-tar products. There were produced in the United States (not inclusive of explosives and synthetic phenolic resins) 54,367,994 pounds of dyes and other finished products, which have a total value of \$68,711,228. The production of the materials known as intermediates amounted to 322,650,531 pounds, with a value of \$106,942,918. The annual production was reported for the following groups of products made in whole or in part from materials derived from coal tar: 45,977,246 pounds of dyes valued at \$57,796,027; 5,092,558 pounds of color lakes valued at \$2,764,064; 2,236,161 pounds of medicinal chemicals valued at \$5,600,237; 779,416 pounds of flavors valued at \$1,862,456; 263,068 pounds of photographic chemicals valued at \$602,281; and 19,545 pounds of perfume materials valued at \$125,960.

There were 81 establishments engaged in the manufacture of coal-tar dyes in 1917 and their production during that year was practically identical with the amounts annually imported before the war. The imports for the fiscal year 1914 amounted to 45,840,866 pounds and the production in the United States in 1917 was 45,977,246 pounds. However, an analysis of this total reveals that the domestic production, though equal in quantity to the preceding imports, differs in the relative amounts of the various classes of dyes. Only a small production was reported for indigo, and the alizarin and vat dyes derived from anthracene and carbazol—classes of dyes which include some of the best and fastest colors known to the textile trade. The United States produced only 2,166,887 pounds of these dyes in 1917; and the elimination of 1,876,787 pounds of extract made from imported indigo reduces the output of these dyes to less than three per cent of the pre-war imports. Dyes of this class are dutiable at 30 per cent in the Tariff Act of 1916. The lack of development in the remedied to a considerable extent in 1918, for a number

of firms have begun their manufacture and a large increase in production can clearly be foreseen.

In the classes of dyes which if imported would be manufacture of these particular dyes promises to be dutiable at 30 per cent plus five cents a pound, the American manufacturers have shown remarkable progress, producing 43,810,359 pounds at a total value of \$57,639,990. That this

represents something of an excess over the American needs is evidenced by the fact that during the fiscal year 1917, American-made dyes to the value of \$11,709,287 were exported to other countries. Thus the exports exceeded the pre-war imports in total value although not in tonnage nor in the variety of the dyes. The developments of the manufacture of intermediates is equally marked, for before the war almost all of these necessary materials were imported from Germany. The Tariff Commission finds that intermediates

### Value of 1917 Exports Exceeds 1914 Imports

|              |              |
|--------------|--------------|
| Imports 1914 | \$ 9,102,066 |
| Exports 1917 | 11,709,287   |

### Tonnage of 1917 Production Exceeds 1914 Imports

|                       |            |
|-----------------------|------------|
| Imports 1914, lb.     | 45,840,866 |
| Production, 1917, lb. | 45,977,246 |

### Production and Value, 1917

|                     | Pounds      | Value        |
|---------------------|-------------|--------------|
| Coal Tar Dyes       | 45,977,246  | \$57,796,027 |
| Color Lakes         | 5,092,558   | 2,764,064    |
| Medicinal Chemicals | 2,236,161   | 5,600,237    |
| Flavors             | 779,416     | 1,862,456    |
| Photo Chemicals     | 263,068     | 602,281      |
| Perfume Materials   | 19,545      | 125,960      |
| Total Dyes, etc.    | 54,367,994  | \$68,711,025 |
| Intermediates       | 322,650,531 | 106,942,918  |

were manufactured by 117 firms in 1917 and that the production amounted to 322,650,531 pounds valued at \$106,942,918. These figures, however, are somewhere misleading as there is inevitable duplication in the totals. It is well known that many of the intermediates are derived from other products of the same class. Thus starting with benzol the following succession of products is obtained: nitrobenzol, anilin, acetanilid, nitroacetanilid, and nitranlin. Each of these products had to be reported by the manufacturer and hence there has been some cumulative counting.

The totals for all of the coal-tar products will be published in the final report which may well be expected to offer accurate evidence on the progress of the American dyestuff industry.

### German Institute for Metallurgical Research

About a year ago a special research laboratory was planned to promote the progress of German metallurgy with a view to the exceedingly keen competition to be anticipated after the war. The location of the research institute will be in the Rhenish-Westphalian industrial region, and the considerable funds required for the construction and maintenance will be provided largely by the iron and steel industry, which probably will be most affected.

## U. S. Tariff Commission Holds Hearings on Tungsten at Denver

The meeting of the United States Tariff Commission was held in the District Court Room, Federal Building, at 10 a.m. June 17, to receive testimony from the producers of tungsten of Boulder County, Colorado, on the need of a tariff to protect their industry.

The Commission was represented by Mr. E. P. Costigan and by its Metallurgical Expert, Mr. Guy C. Riddell.

Among the operators presenting testimony were: Mr. Warren Bleecker, President of the Tungsten Products Company, Boulder. Mr. Harold Boericke of the Primos Chemical Company. Mr. William Loach of the Wolf-tung Mining Company. Mr. John A. McKenna of the Vasco Mining Company. Mr. John G. Clark of the Boulder Tungsten Production Company. Mr. Nelson Franklin of the Rare Metals Ore Company. Mr. William Coudrey of the Long Chance Mining Company. Mr. I. N. Bair, leaser on the Good Friday Mine. Mr. Edwin E. Chase, Mining Engineer of Denver. Mr. Emerson J. Short of the Union Mine and Development Company, Denver. Mr. Stoddard of the Black Metals Company, Boulder.

MR. WARREN F. BLEECKER presented a report signed by the operators of Boulder County through their Committee asking that they be given protection by a tariff which would raise the price of 60 per cent concentrate to \$30 to \$40 per unit.

The Boulder County Committee was of the opinion that the adequacy of American deposits for domestic needs is largely dependent upon the price and stability of the market. In 1917 there was produced in Boulder County from 2800 to 3000 tons of concentrates requiring the labor of approximately 750 men. At one time during the boom in 1915-1916 as many as 3000 men were directly employed in the tungsten industry in Boulder County, showing that an increase in the price causes very many more people to engage in the industry.

Mr. Bleecker then took up some of the metallurgical details of Boulder County practice, showing that an average recovery was 75 per cent, and that on the horn ores they only made 50 per cent recovery. He showed that due to the fine grind necessary to removing the gangue material there was a heavy slime loss, and stated that there was no new satisfactory process for slime recovery. He stated that whereas ferberite had always been considered the best material for the electric furnace manufacture of ferrotungsten, scheelite was now being used successfully and was commanding a premium for this work which formerly had been commanded by ferberite. He stated that the high phosphorus on the Boulder County concentrate compelled the refining process which was not necessary with scheelite. He felt that there has been much misinformation spread as to the impurity of foreign ores, as most of the foreign ores were as pure as our ore. He felt that a price of \$30 to \$40 per unit should be established for 60 per cent tungsten concentrate.

MR. NELSON FRANKLIN of the Rare Metals Ore Company gave some typical figures of actual expenditures in the production of 60 per cent concentrate from the mining operations of the Tip-Top Leasing Company and the Black Metals Mining Company. These were the only

### COST OF PRODUCING TUNGSTEN CONCENTRATE THE BLACK METAL MINES COMPANY STATEMENT OF PRODUCTION COST, 1917

| Total Expenditures                          | Production  |           | Units WO <sub>3</sub> | Cost Per Unit |
|---------------------------------------------|-------------|-----------|-----------------------|---------------|
|                                             | Tons        | Per Cent. |                       |               |
| Brace tract.....                            | \$4,406 26  | 10 75     | 1 03                  | 11            |
| Manchester.....                             | 19,224 18   | 1,210 0   | 1 88                  | 2,280         |
| Whitney.....                                | 1,562 40    |           |                       |               |
| Pactwa.....                                 | 83 49       |           |                       |               |
| Connet.....                                 | 113 14      |           |                       |               |
| Bishop.....                                 | 2,384 80    |           |                       |               |
| Ecker.....                                  | 1,524 51    | 2 08      | 1 84                  | 4             |
| Totals.....                                 | \$29,298 78 | 1,222 83  | Avg. 1 876            | 2,295         |
| Total Units Produced                        |             |           | 2 295                 |               |
| Less 20% loss in milling.....               |             |           | 0 459                 |               |
| Net units recovered.....                    |             |           | 1 836                 |               |
| Less 20% royalty to owners of property..... |             |           | 0 367                 |               |
| Net units recovered for sale by us.....     |             |           | 1 469 =               | \$19.82       |
| Hauling charges on 1,222 83 tons @ \$2.00 = |             |           | \$2,445 86            | 1 33          |
| Milling charges on 1,222 83 tons @ 6.00 =   |             |           | 7,336 98              | 3 99          |
| Total cost per unit produced.....           |             |           |                       | \$25.14       |

The royalty is based on the recovery in concentrates and owners of the properties under lease pay their proportion of the hauling and milling charges, hence these costs are divided by the net recovery in concentrates from the mill, whereas the net cost to us is based on the net recovery by us on our proportion of the recovery in concentrates.

### THE TIP TOP LEASING COMPANY STATEMENT OF PRODUCTION COST 1917 AND 1918

|                                                                                                                                                       |              |
|-------------------------------------------------------------------------------------------------------------------------------------------------------|--------------|
| Total expenditures.....                                                                                                                               | \$25,220.84  |
| We have been developing the mine during the winter and on account of snow being very deep could not commence to haul ore to the mill until June 10th. |              |
| Our engineers estimate that we have 2,000 tons of ore developed, of an average grade of 1.10% WO <sub>3</sub> .                                       |              |
| 2,000 tons @ 1.10%.....                                                                                                                               | 2 200 units  |
| Less loss in milling 20%.....                                                                                                                         | 0 440 units  |
| Net units recovered.....                                                                                                                              | 1 760 units  |
| 15% royalty to owners' property.....                                                                                                                  | 0 264 units  |
| Net units recovered by us for sale.....                                                                                                               | 1 496 units  |
| Mining cost yet to extract ore 1,800 tons. \$4.00 per ton.....                                                                                        | \$7,200.00 = |
| Hauling charges on 2,000 tons @ \$4.00.....                                                                                                           | 8,000.00 =   |
| Milling 2,000 tons @ \$6.00.....                                                                                                                      | 12,000.00 =  |
| Total cost per unit produced.....                                                                                                                     | \$31.84      |

The royalty of 15% is based on the recovery in concentrates and the owner of the property has to pay his proportion of the hauling and milling charges, hence these costs are divided by the net recovery in concentrates from the mill, whereas the net cost to us is based on the net recovery by us on our proportion of the recovery in concentrates.

### COST OF MANUFACTURE FERROTUNGSTEN, FERRO ALLOY COMPANY, JUNE, 1917

|                                                  | Pounds       |
|--------------------------------------------------|--------------|
| Concentrate smelted.....                         | 19,520.00    |
| Tungsten contained.....                          | 9,325.4      |
| Ferrotungsten produced.....                      | 10,095.00    |
| Tungsten contained in ferrotungsten.....         | 7,167.45 lb. |
| Tungsten contained in residues.....              | 962.00 lb.   |
| Total recovered tungsten.....                    | 8,129.45 lb. |
| Percentage recovery of tungsten.....             | 87.1         |
| Ferrotungsten on hand June 30th.....             | 15,185.00    |
| Tungsten contained in ferrotungsten on hand..... | 10,781.35    |
| Tungsten contained in residues.....              | 962.00       |
| Total tungsten on hand.....                      | 11,743.35    |

### COST OF MANUFACTURE OF FERROTUNGSTEN, JUNE, 1917. BASED ON A PRODUCTION OF 10,095 LB. FERROTUNGSTEN, CONTAINING 7,167.45 LB. W.

|                                             | Total       | Per Pound Tungsten |
|---------------------------------------------|-------------|--------------------|
| Supervision.....                            | \$290.00    | \$0.040            |
| Laboratory expense—chemist.....             | \$72.50     |                    |
| supplies.....                               | 22.06       |                    |
| Labor.....                                  | 94.56       | 1.014              |
| Power, 59,346 kw.-hr., cost 0.73 cents..... | 609.60      | 0.085              |
|                                             | 432.60      | 0.060              |
| Supplies:                                   |             |                    |
| Electrodes.....                             | 131.69      | 0.018              |
| Refractories.....                           | 146.42      | 0.021              |
| Miscellaneous.....                          | 25.00       | 0.003              |
| Charge—fluxes, etc.....                     | 53.86       | 0.008              |
| Tools.....                                  | 58.00       | 0.008              |
| Repairs and renewals.....                   | 77.40       | 0.011              |
| Sales expense.....                          | 37.14       | 0.005              |
| Office.....                                 | 82.05       | 0.012              |
| Insurance.....                              | 43.26       | 0.006              |
| Total operating.....                        | \$2,081.58  | \$0.291            |
| Ore cost—charged to FeW.....                | \$11,647.06 |                    |
| Less residues*.....                         | 1,102.50    |                    |
|                                             | \$10,544.56 | \$1.475            |
| Total.....                                  | \$12,626.14 | \$1.766            |

\* Tungsten in residues credited at \$1.25 per lb. W, which was cost with 20% concentrate.

This cost statement includes all costs up to sale, packing, and shipment from plant. Adding these items gives cost f. o. b. New York:

|                                      |         |
|--------------------------------------|---------|
| f. o. b. plant, operating cost.....  | \$0.291 |
| f. o. b. N. Y., additional cost..... | 0.090   |
| Ore cost.....                        | 1.477   |

Total cost sold and delivered New York, per lb. W..... \$1.856



actual cost figures drawn from the ledger made public at the meeting, although other figures were given as confidential for the use of the Tariff Commission. Copy of these costs is presented herewith.

MR. EDWIN E. CHASE stated that the Good Friday Mine was under lease to I. N. Bair, and that although this mine had one of the best showings of tungsten in the district it could not operate at a profit with concentrate at \$22 to \$25 per unit. In reply to question from the Tariff Commission he stated that he didn't believe that the tungsten resources of Boulder County were by any means exhausted, but that the easily reached deposits were worked out.

MR. EMERSON J. SHORT produced figures attempting to show that all of the profit in tungsten operations was obtained by the mill-man and the ferrotungsten manufacturer. He claimed that the cost of the production of ferrotungsten for operating expenses, but not including the price of ore, was 14¢. per pound of W contained, and that the power cost was approximately 1¢. per pound of W contained. His figures on milling were much lower than those stated by others present.

MR. R. M. KEENEY of The Ferro Alloy Company produced actual cost figures on the manufacture of ferrotungsten showing a cost of about 38.1¢. per pound of W for ferrotungsten delivered in New York. These figures include the entire operating expense and express to New York. He also stated that the Ferro Alloy Company ceased its operations on the manufacture of ferrotungsten and converted its plant into a ferrochrome plant last July because of the fact that at that time tungsten concentrate went to \$27.50 per unit with ferrotungsten remaining from \$2.15 to \$2.25 per pound of contained tungsten. The concentrate cost, under these conditions, was \$2 per pound, which with an operating cost of 38¢. per pound made a total cost of \$2.38 per pound. These figures were corroborated by another producer present. A copy of the cost of the manufacture of ferrotungsten by the Ferro Alloy Company, June, 1917, is given herewith.

A representative of the Miners' Union from Nederland, Colorado, who was also a leaser, stated that the miners were not getting enough pay; that instead of a \$4 a day minimum they should get \$5 a day minimum. However, he said that, as a leaser, he could not afford to pay any higher wages as he had a very close margin of profit with present wages, and felt that the only way to get higher wages was to put the price of tungsten concentrate up to \$30 to \$35 per unit. He felt that rather than establish the price of concentrate on the basis of 60 per cent, some means should be taken to arrange a definite schedule for ores from 1½ up to 60 per cent, as he felt that the miners never knew what price they were going to get for concentrate until it was shipped to the mill and that the mill did not pay them a high enough price. Several present showed that the mill was paying all that it could afford to pay, but there was a general consensus of opinion that rather than establish a price of concentrate the price should be established on certain grades of ore so that the miner could look forward to a fixed price. Part of this testimony was considered by the Tariff Commission to be evidence more for the fixation of a price on tungsten rather than showing the need of a tariff to protect the producer of ore.

## Water-Power Committee Agrees on Bill

THE special committee appointed in the House of Representatives to consider all proposals for water-power legislation has completed its work and has agreed upon a bill which will be presented to Congress probably early in July. The bill is practically identical with what was known as the Administration Water Power Bill which was made the subject of hearings that have been previously reported<sup>1</sup>.

In its essential features the bill provides for a Federal Power Commission consisting of the Secretaries of War, Agriculture and the Interior. The President is to designate the chairman of the commission, which is to issue licenses for the development of water power projects, the term of the license to be not exceeding 50 years.

The original definition of net investment is retained. The bill also contains the original options regarding the disposition of the project at the end of the 50-year license period, and relating to the regulation of rates of service and character of securities.

A new provision was written into the bill requiring the licensee to maintain out of surplus earnings, if any, accumulated in excess of a specified rate of return upon the net investment, amortization reserves to be held until the termination of the license or applied periodically in reduction of the net investment. The license may provide that any balance or surplus earnings shall be used in reduction of rates and annually returned to the consumer.

## Steel Prices Fixed for Three Months

The President has approved the agreement made by the Price-Fixing Committee of the War Industries Board with the representatives of the iron ore, pig iron and steel interests, that the maximum prices now prevailing on iron ore, pig iron and iron and steel products be continued in effect for the three months ending September 30, 1918, with the following exceptions:

### 1. Lake Superior Iron ore:

Base prices of Lake Superior iron ore delivered to lower Lake ports are increased 45¢. per gross ton on and after July 1, 1918, subject to the following condition: These increased prices are based on the advances in rail freight rates effected June 25, 1918, and on the present lake rates and in the event of any increase or decrease in either rail or lake rates said prices shall be increased or decreased accordingly on all deliveries made during the continuance of such increased or decreased freight rates.

### 2. On and after July 1, 1918, the basing point for steel bars, shapes and plates will be Pittsburgh, Pa.

No new contracts calling for delivery of any of the above commodities or articles on or after Oct. 1, 1918, are to specify a price unless coupled with a clause making the price subject to revision by any authorized United States Government agency, so that all deliveries after that date shall not exceed the maximum price then in force, although ordered or contracted for in the meantime. It is expected that all manufacturers and producers will observe the maximum prices now fixed.

<sup>1</sup>This Journal, Vol. XVIII, No. 5, (Mar. 1, 1918, p. 225), *en. 6.* (Mar. 15, 1918, p. 286), No. 7, (Apr. 1, 1918, p. 339), No. 9, (May 1, 1918, p. 439), and No. 11, (June 1, 1918, p. 568).

## The President's Readjustment and Reconstruction Commission—II.

### Elaborate Preparations Already Made by England's Ministry of Reconstruction

BY WINGROVE BATHON

Washington Representative, McGraw-Hill Co., Inc.

THE previous article in this series suggested and urged the appointment by the President of the United States of a readjustment and reconstruction commission, to begin to deal now with vital problems in industry which will be presented after the war. It was pointed out that many other countries, notably Great Britain, have already begun to attempt to solve after-the-war problems. The personnel of a suitable commission, selected from the ranks of American industry, and of an advisory council, taken from the ranks of Government officials, to work with such a commission, was suggested in detail.

Some of the far-reaching work being done along this line by Great Britain is now presented as an evidence that it is necessary for American industry to begin now to prepare to solve after-the-war problems. This description of Great Britain's Ministry of Reconstruction is taken from the official reports to Parliament of the British War Cabinet, furnished to the writer for the purpose of this article by Arthur Willert, Secretary of the British War Mission at Washington. These reports are inclusive of the year 1917 and have just been sent to Washington.

#### BRITISH MINISTRY OF RECONSTRUCTION

After tracing the earlier stages of the Ministry of Reconstruction in Great Britain, before it was established by the New Ministries Act, in July, 1917, and when the agency of reconstruction consisted of a committee of Ministers of the Crown, the War Cabinet reported that it was found necessary to establish a Ministry of Reconstruction to continue for the duration of the war and for a period of two years, or less, after its conclusion. It was declared that a Prime Minister upon whose shoulders fell the responsibility for the conduct of the war could not personally assume a day-to-day responsibility for guiding the Reconstruction Committee's work. It was stated that the Government had throughout been aware that as the war continued, and its pressure upon every side of the national life increased, the intensity of the struggle in itself enhanced the importance of the reconstruction problems which had to be faced; and that Parliament and the country were not slow in realizing that there was coming into existence a series of questions of the utmost importance to which answers must be found, not after, but before, the conclusion of the war.

The functions of the Minister of Reconstruction then appointed and who assumed office in August, 1917, are defined as follows:

"To consider and advise upon the problems which may arise out of the present war and may have to be dealt with upon its termination, and for the purposes aforesaid to institute and conduct such inquiries, prepare such schemes, and make such recommendations as he sees fit; and the Minister of Reconstruction shall, for the purposes aforesaid, have such powers and duties of any

Government department or authority which have been conferred by or under any statute as His Majesty may by Order in Council authorize the Minister to exercise or perform concurrently with, or in consultation with, the Government department or authority concerned."

In other words, as was brought about during the debate which resulted in the creation of the Ministry, the Minister in charge does not exercise executive functions; he appoints committees; he initiates experiments; he frames schemes for action with a view to conditions after the war; his powers are not exclusive and do not shut out other departments; he assists the other departments, provides them with information and helps them "to build a bridge which will safely carry us over from war to peace conditions." The British Parliament found that the creation of a reconstruction agency was desirable because various government departments are approaching various problems in their own way, each drawing up reports or memoranda, and that what was needed was a co-ordinating element, not especially attached to the work or to the traditions of any one of the departments concerned. The Solicitor-General of Great Britain, speaking in debate, said that what was needed was a "comprehensive co-ordinating mind, a fresh mind, and at the same time an authoritative mind, who will bring together the several contributions of the various specialized departments."

#### BRANCHES OF THE BRITISH MINISTRY

The Ministry of Reconstruction was then formed. For the purposes of administration the department was divided into branches dealing respectively with Commerce and Production, including the supply of materials; with Finance, Shipping and Common Services; with Labor and Industrial Organization; with Rural Development; with the Machinery of Government (Central and Local); Health and Education; and with Housing and Internal Transport.

The Minister of Construction then appointed an Advisory Council, "representative of all the leading interests concerned in reconstruction, and it is his hope by consulting the Council freely and regularly to secure a representative consensus of opinion on any proposal which may be referred to him for advice or which may be initiated in the department." This Council is organized very much as the Pan American Financial Conference held in Washington at the beginning of the war was organized, and very much as the old War Industries Board of the Council of National Defense of the United States was organized. In other words, there are experts in each line named to serve the government representatives. The Council is divided into sections, just as the administration of the Ministry of Reconstruction is divided. It is stated that "the membership of the Council has been so arranged that in each section all the principal interests represented on the Council should find a place; thus, there are representatives of labor on the finance section as well as financiers; there are business men as well as agriculturists on the section dealing with agriculture; and so on."

The meetings of the sections of the Ministry and the Council are private, but it is known that they have already dealt with the standardization of railway equipment; the post-war rationing of industries; the establishment and functions of trade organizations; the or-

ganization of rural information centers; the establishment of industrial courts; house planning from the point of view of domestic economy; the future organization of voluntary women's work; and the conditions required for maintaining a supply of efficient agricultural labor.

#### WORK ALREADY ACCOMPLISHED BY DIFFERENT SECTIONS

The section dealing with commerce and production is investigating (1) the supply and control of raw materials after the war; (2) financial facilities for British commerce and industry after the war; (3) the preservation of industries which will play an essential part in reconstruction but are in extinction through failure of supplies of material or labor; (4) financial risks attached to the holding of trading stocks; (5) trusts and combinations with special reference to the protection of the consumer; (6) the establishment of new industries after the war, a committee having been especially appointed to consider this question as far as the engineering industries are concerned, a parallel committee considering the labor questions involved; (7) the volume and nature of the demand for British goods after the war; and (8) improvements in trade organization for the purpose of more economical production, distribution, and marketing, and expediting the turnover from war to peace.

The section dealing with finance, shipping and common services is, in conjunction with the Treasury, considering the question of currency and exchange after the war; and under this section an Advisory Council section is at work on the disposal of government stores after the war.

#### CONFERENCE OF TRADE ORGANIZATIONS

The section dealing with labor and industrial organizations has agreed with the British Board of Trade and the Ministry of Labor that "a concerted effort should be made to promote in as many industries as possible representative organizations to advise the Government as to the views and needs of the industries on the various industrial and commercial problems that will affect them during the reconstruction period. The Ministry of Labor is to proceed with the formation of permanent industrial councils. A conference of trade organizations is being established by the Ministry of Reconstruction, consisting of three employers, three trade unionists and representatives of the Board of Trade, the Ministry of Labor and the Ministry of Reconstruction. The Minister of Reconstruction has decided to refer to the Industrial Section of the Advisory Council the question of establishing corresponding organizations in engineering and in railways.

This section, (dealing with labor and industrial organizations) is farther along with its work than any of the other sections, apparently; for reports have been submitted on unorganized trades and works, and, probably by now, on conciliation and arbitrations. A general survey of industrial policy as a whole has been prepared, going into the law and labor in merchant shipping, war-time departures from trade-union practices, industrial courts, industrial structures, apprenticeship, the reinstatement of returning soldiers and sailors and international labor legislation. Furthermore, surveys have been undertaken of industrial methods; inquiry is

being made into juvenile employment; the question of army demobilization, it has been settled, makes the Ministry of Labor responsible for the returned soldier or sailor, and the Ministry of Reconstruction is to determine the priority of different trades. A complete list of public works which have fallen into arrears has been prepared so that surplus labor may be usefully and rapidly employed; and the Ministry of Munitions has begun work on the special problems arising out of its work.

#### RURAL DEVELOPMENT BEING STUDIED

The section dealing with rural development is examining (1) the working of the Small Holdings Act and the future of Urban War Allotments; (2) a report made by the Forestry Committee; (3) the rural housing problems; (4) the organization of County Offices for advice on agriculture; (5) tithe redemptions; (6) village industries; and (7) the report of the Land Acquisition Committee.

The section dealing with Machinery of Government, Health, Education, etc., is negotiating through a committee on the distribution of functions in regard to the formation of a Ministry of Health and is studying reports which have been made (1) on the functions of the Poor Law Authorities; and (2) on Adult Education.

The section dealing with Housing and Internal Transport, with a view to facilitating work in connection with housing, has set to work committees on (1) supply of building materials; (2) house building construction and on (3) building by-laws. Special investigations are being made by this section on (1) control of public utility societies; (2) town planning; (3) rings in the building trade; (4) the working of the Small Dwellings Acquisition Act; and a general review of the problem of inland transport is being made, the portions dealing with roads and canals having been completed. Furthermore, the Ministry is in consultation with the Board of Trade concerning the future of the railways (including light railways) of Great Britain and an inquiry has been begun into the question of storage and distribution as essential elements in transport policy.

#### SHORTAGE OF MATERIALS AND TONNAGE AFTER THE WAR

This article is intended to be but a brief outline sketch of the monumental amount of work being done by the British Ministry of Reconstruction, but it might be well here to hark back for a moment or two to some of the points being taken up by the various sections. In the section dealing with commerce and production, the report of the British War Cabinet to Parliament states that the question of the "volume and nature of the demand for British goods after the war" and the question of "improvements in Trade Organization for the purposes of more economical production, distribution and marketing and of facilitating the turnover from war to peace" are being handled in consultation with the British Board of Trade and the Department of Overseas Trade, and that "a comprehensive scheme of work has been prepared." The British Cabinet thus states the problem.

"After the war there will be a world shortage of certain materials and the shortage will be accentuated by the difficulty of finding tonnage adequate to our demands. On the other hand, there will be an almost unlimited demand for manufactured goods."



## Triplex Process of Making Electric Steel\*

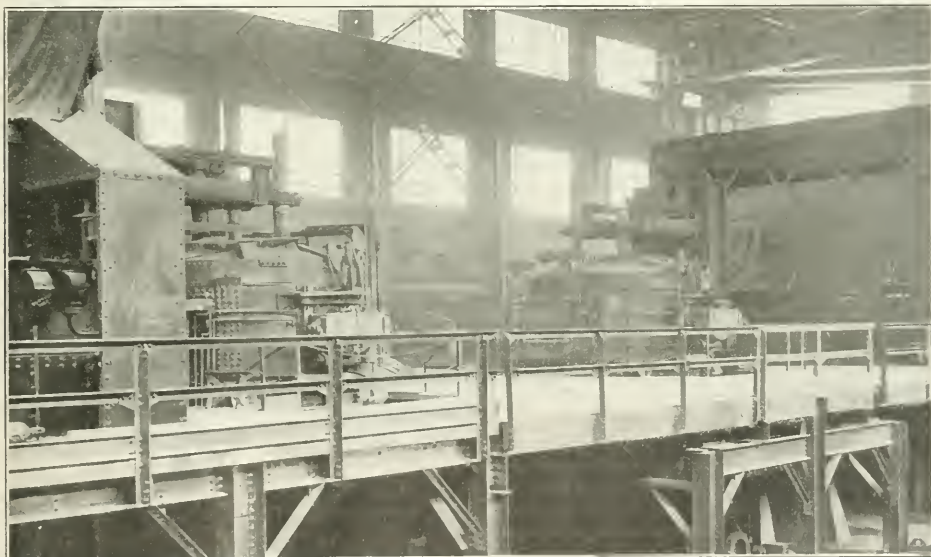
Development at South Chicago of the World's Largest Electric Steel Plant Comprising Three 25-ton Heroult Furnaces—Superiority of Electric Steel—Increase in Production in Ten Years

By THEODORE W. ROBINSON

THE development of electric steel at South Chicago was based upon the fundamental conception that the electric furnace was pre-eminently adapted to the manufacture of carbon and alloy steel of the highest quality, that it would be possible to produce electric steel in sufficiently large units to permit its use in heavy products, and that the increasing demand for high-grade steel would provide a sufficiently extensive market to make its manufacture commercially possible.

Under these promises, the Illinois Steel Co., in May, 1909, installed its first electric steel furnaces at the South Chicago works. At that time there were only two other electric furnaces in this country concerned

As the fundamental object was to demonstrate the opportunities of the new process in connection with heavy products, attention was early turned to the experimental manufacture of electric steel rails. Under the limitation of equipment, it was necessary to depart from standard rail practice to the extent of accumulating cold ingots and re-heating them. The electric steel used was made from Bessemer blown metal. We advisedly felt our way in chemistry. Irregularities incident to incomplete equipment were unavoidable. In spite of pioneering difficulties, about 10,500 tons of electric steel rail were laid on 14 railroads throughout the country. The result of these rails in track indicated



TWO OF THE THREE 25-TON HEROULT ELECTRIC FURNACES

with the manufacture of electric steel—one at the Halcomb Steel Co., Syracuse, N. Y., and the other at the Firth Sterling Steel Co., McKeesport, Pa. The furnaces here and abroad were all small, running from a ton or less to five tons in capacity. Our installation consisted of a 15-ton basic-lined Heroult furnace with an electric equipment for 3-phase, 25-cycle, and 100-volt current. The manufacture of electric steel was a new art and ours was a new adaptation of a new art. As to the troubles we encountered, I may say their name was "Legion." Perseverance conquered, however, and we soon had the satisfaction of producing a metal of unquestionably superior quality.

that electric and openhearth rails of like chemical composition had practically the same resistance to wear when the former were made under the conditions that existed at the time of their manufacture. The failure from breakage was almost negligible, there were no interior defects and the tests showed that the electric steel was considerably more ductile at low temperature than either the openhearth or the Bessemer steel.

In order to further determine the facts, a series of experiments was undertaken with a view of testing the ductility of rail steel at low temperatures. A refrigerating plant was erected adjacent to our regular drop-testing machine. About 900 pieces of electric, openhearth, and Bessemer rails of various sections were tested at temperatures ranging from 70 deg. Fahr. to

\*Excerpt of a paper presented at the fourteenth general meeting of the American Iron and Steel Institute in New York, May 31, 1918. The author is first vice-president of the Illinois Steel Co.

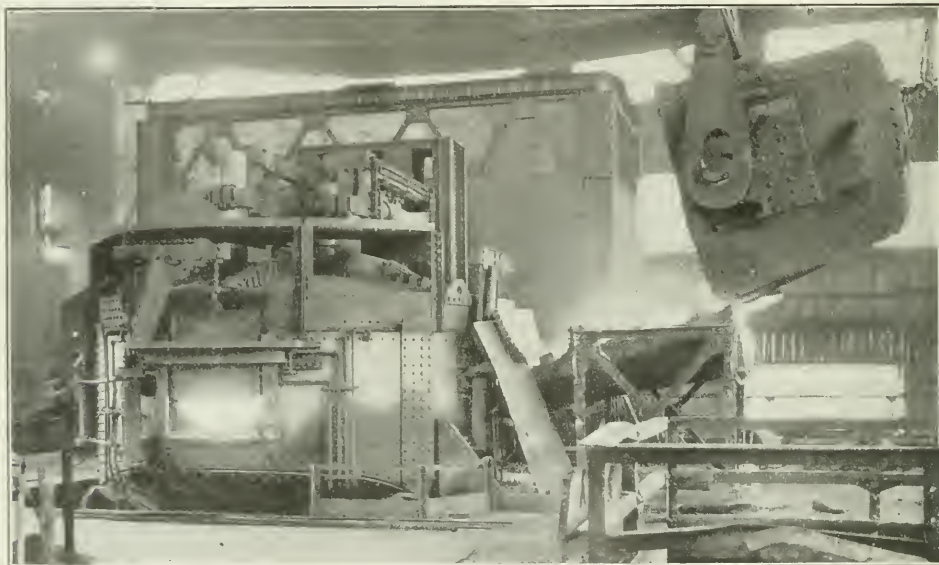
50 deg. below zero. These tests emphasized that, in the case of all the steels, there was a marked decrease in resistance to shock as the temperature lowered. Relatively speaking, however, the electric steel was distinctly more ductile than either the Bessemer or openhearth. The following summary from two electric and two openhearth heats of similar analysis involving 242 tests is typical of the general results obtained. The figures in Tables II, III and IV are average results. The chemical composition of the heats is given in Table I.

In all these tests the height of drop was kept comparative. At normal temperatures 18 ft. was employed. At zero Fahrenheit and below, the steel, weakened by

facturing electric steel rails, we were experimenting with such other heavy products as forgings, plates, axles, and structural shapes. Not only had carbon steel been made in relatively large quantities in connection with these products, but the field of alloy steel had been comprehensively entered. Expanding demand led to the introduction in July, 1916, of a second furnace, similar to the original one in electrical equipment and capacity. This gave a combined capacity of about 4500 tons of electric steel ingots per month.

#### LARGE ELECTRIC FURNACES JUSTIFIED

By this time our experience had verified in a large measure the soundness of the views upon which our



POURING OPEN-HEARTH METAL INTO ONE OF THE 25-TON HEROULT ELECTRIC FURNACES

the cold, could not withstand so heavy a blow, and the drop was reduced to 8 ft. While it is self-evident that the number of heats involved in the above tables is entirely too small to permit the drawing of definite conclusions, the fact that the other drop tests and the result of the rails in track all pointed in the same direction warrants the belief that the resistance to dynamic force rapidly decreases with lower temperature in the case of both openhearth and electric steels and that electric steel is tougher than openhearth steel at low temperatures.

During and after the period in which we were manu-

original electric furnace installation was predicated. We had demonstrated that it was possible to produce electric steel in relatively large units without the sacrifice of quality. The physical characteristics of the steel had proved to be admirably adapted for heavy products. There was a growing demand for a superior steel for general purposes, and the call for alloy steels was rapidly increasing in connection with the automobile and other industries. Extent of market was largely a question of price, and price logically was largely a matter of cost.

In the meantime an addition to our openhearth at

TABLE I.—COMPOSITION OF THE RAIL STEELS

|                         | Carbon,<br>Per Cent | Manga-<br>nese,<br>Per Cent | Phos-<br>phorus,<br>Per Cent | Sulphur,<br>Per Cent | Silicon,<br>Per Cent |
|-------------------------|---------------------|-----------------------------|------------------------------|----------------------|----------------------|
| First electric heat     | 0.64                | 0.60                        | 0.024                        | 0.019                | 0.216                |
| First open-hearth heat  | 0.62                | 0.71                        | 0.020                        | 0.040                | 0.140                |
| Second electric heat    | 0.73                | 0.90                        | 0.022                        | 0.043                | 0.236                |
| Second open-hearth heat | 0.72                | 0.88                        | 0.035                        | 0.033                | 0.200                |

TABLE II.—AVERAGE NUMBER OF BLOWS REQUIRED TO BREAK THE RAILS

| Temperature | Electric | Open-Hearth | Comparison             |
|-------------|----------|-------------|------------------------|
| *+60 deg. F | 3.48     | 3.64        | O. H. 5% over Elect.   |
| 0 deg. F    | 4.41     | 3.82        | Elect. 15% over O. H.  |
| -30 deg. F  | 4.55     | 2.24        | Elect. 103% over O. H. |
| -40 deg. F  | 3.31     | 2.03        | Elect. 65% over O. H.  |

TABLE III.—DEFLECTION BEFORE BREAKING BLOW

| Temperature | Electric | Open-Hearth | Comparison             |
|-------------|----------|-------------|------------------------|
| *+60 deg. F | 2.96 in. | 3.36 in.    | O. H. 14% over Elect.  |
| 0 deg. F    | 1.41 in. | 1.23 in.    | Elect. 15% over O. H.  |
| -30 deg. F  | 1.46 in. | 0.58 in.    | Elect. 152% over O. H. |
| -40 deg. F  | 0.91 in. | 0.43 in.    | Elect. 112% over O. H. |

TABLE IV.—ELONGATION IN 12 INCHES MEASURED AFTER LAST BLOW BEFORE THE DESTRUCTION

| Temperature | Electric  | Open-Hearth | Comparison             |
|-------------|-----------|-------------|------------------------|
| *+60 deg. F | 0.808 in. | 0.929 in.   | O. H. 15% over Elect.  |
| 0 deg. F    | 0.404 in. | 0.397 in.   | Elect. 2% over O. H.   |
| -30 deg. F  | 0.420 in. | 0.201 in.   | Elect. 109% over O. H. |
| -40 deg. F  | 0.297 in. | 0.141 in.   | Elect. 111% over O. H. |

\* 60 deg. F.—18 ft. drop. Zero deg. F. and below—8 ft. drop.

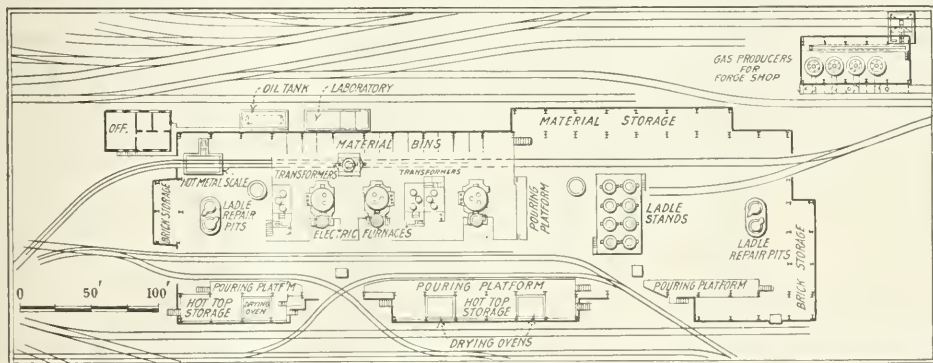
South Works had become desirable and in connection therewith the matter of increasing our electric steel capacity was taken under consideration. In studying this subject, we were naturally guided by our past experience. We had made electric steel by the melting of cold stock. We had refined in the electric furnace both molten blown Bessemer metal and molten openhearth metal. We also had made steel by the initial refining of Bessemer blown metal in the openhearth, supplemented by final refining in the electric furnace. Part of this work was experimental in character. None of it was done under ideal economic conditions. The cost of producing steel in the electric furnace was vitally influenced, of course, by the amount of power used, and this and other conversion items were in turn largely influenced by the tonnage produced. Manifestly nothing could be considered that would sacrifice quality for output without destroying the very essence and reason for the electric process.

As electricity is an expensive metallurgical fuel, the melting of cold stock or the preliminary refining of metal in the electric furnace could be accomplished only at the expense of a comparatively high fuel cost. Our original practice was to make electric steel by refining

clear that for the simultaneous production of Bessemer, openhearth and electric steel, extreme elasticity of operation was fundamental if efficiency was to be attained. Close assembly of the various units was essential for rapid and economical practice. The sequence of operation had to be unobstructed. A supply of hot pig metal and preliminary refined molten steel must be provided. The plant as finally designed, both in respect to its general plant location and its general details of construction, is shown by illustrations.

Inasmuch as this paper deals specifically with electric steel, no attempt will be made to give a detailed description of the Bessemer and openhearth refining as carried out in the new plant at South Chicago. The metallurgy and manipulation present little that is novel.

There are two main buildings; one comprising the duplex plant proper, and the other, parallel thereto, containing the electric furnaces. As an adjunct to the latter, there was installed a 1500-ton forge press. In its essential features, the duplex plant consists of two mixers, one of 100 tons and one of 300 tons capacity; two 25-ton acid-lined converters, and three 250-ton tilting openhearth furnaces. The mixers are commanded by two cranes, one of 100-tons and one of 75-tons ca-



THE ELECTRIC FURNACE DEPARTMENT OF THE TRIPLEXING PLANT

Bessemer blown metal. This process necessitated two distinct operations in the electric furnace, namely, dephosphorization by the use of an oxidizing slag, and deoxidization by means of a reducing slag. Steel of the highest quality can be produced by this practice, but there is obviously greater liability to irregularity in this method than when openhearth metal is used from which the phosphorous previously has been eliminated.

It is well to remember that the electric furnace, while a highly efficient instrument, is far from fool-proof. Several years' experience with the use of Bessemer blown metal in the stationary openhearth furnaces under the local conditions that existed had helped to demonstrate the advantages of the duplex process for producing openhearth steel. It likewise had been shown that electric steel could be most advantageously produced at South Chicago by using openhearth metal.

It was essential that the proposed plant should be so designed as to provide not only Bessemer metal for openhearth refining and openhearth metal for electric refining, but Bessemer ingots and openhearth ingots as well. Many new problems were involved. It was

capacity, and the mixer metal is transferred on an elevated platform to the converters by a 25-ton transfer ladle operated by cable and winch mechanism.

When used in the openhearth furnaces, two heats of Bessemer blown metal are poured into a 65-ton ladle commanded by a narrow-gage locomotive. Elimination of slag is accomplished by nozzle pouring into a second ladle. When Bessemer ingots are to be produced, the metal from one vessel is poured into a smaller ladle and transferred to the Bessemer pouring platform. The three tilting openhearth furnaces, each of which has a hearth area of 892 sq. ft., are electrically operated, and are so constructed as to be heated either with producer gas or with tar. Air chambers having 10,472 cu. ft. of checker volume and gas chambers having 6734 cu. ft. of checker volume provide liberal regenerative capacity. Two low-type 7½-ton charging machines and three 100-ton overhead cranes assure the rapid handling of material. The pit side of the openhearth department, which is generous in its dimensions, is served by two 175-ton cranes, and is provided with a 330-ft. pouring platform capable of handling two sets of molds.

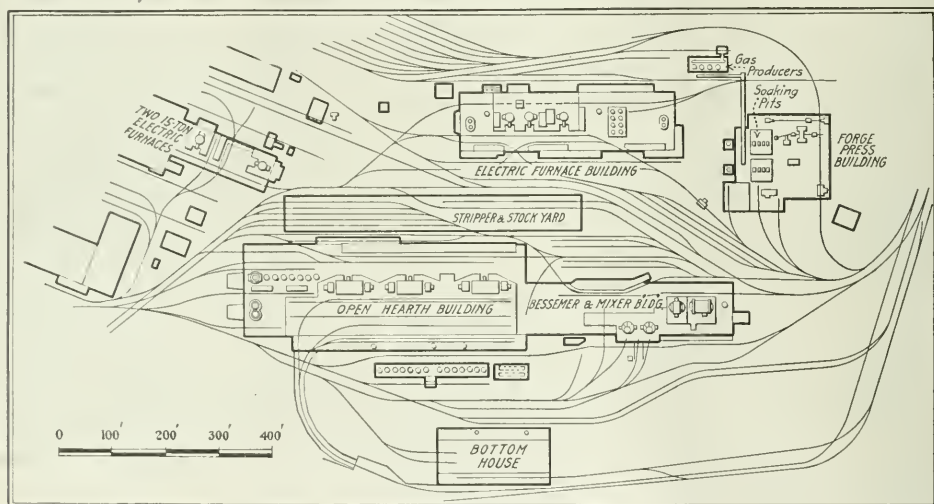


The Bessemer plant is designed for the ultimate addition of a third vessel. Its present capacity may be conservatively placed at 75,000 tons per month of blown metal, Bessemer ingots or any desired combination of the two. The three tilting openhearth furnaces when operating on blown metal are rated at 65,000 to 75,000 tons per month. The elasticity of their operation is self-evident, and it is obvious that their actual tonnage is dependent upon the character of the charge used. At the present time two of these furnaces are running on openhearth material, with Bessemer blown metal as a base. The other furnace is operating on a nickel steel scrap charge with molten pig iron additions for further refining in the electric furnace.

In transferring openhearth metal to the electric furnaces, it is the aim to have the metal slightly lower in carbon and manganese than the specifications under

in the small furnace to consider the losses due to resistance in the electrical current. When we consider the relatively little power required by the original furnaces, it is evident that in the case of our larger furnaces which are equipped with transformers of 3750 kva. capacity, the question of power losses is an important one. In respect to the electric furnace load from the central station standpoint, it is interesting to note that with four furnaces operating on the triplex process, 24-hr. load factors of 75 or 80 per cent are not unusual. This compares favorably with other forms of industrial load.

In our practice, the furnaces ordinarily are operated with only a reducing slag, and care is taken at all times to see that such conditions obtain as will most thoroughly and quickly effect complete deoxidation. After the steel is thoroughly dead-melted and the reactions



THE TRIPLEXING PLANT OF THE ILLINOIS STEEL CO., SOUTH CHICAGO

which the electric steel is to be made. There is, of course, oftentimes a wide range in the specifications under which the electric furnaces are operating, involving high and low carbon and various alloy steels.

### THREE 25-TON HEROULT FURNACES

The new electric plant contains three 25-ton Heroult furnaces, each with an adjacent transformer building. The general design and dimensions are shown by one of the illustrations. The capacity of the plant naturally is somewhat dependent upon the character of the steel made, but may be placed approximately at 12,000 tons per month. This with the output of the two old furnaces gives a total electric steel capacity of 16,000 to 17,000 tons per month, and makes the South Chicago works the world's largest electric steel producing plant.

The advancement in the design and operation of electric furnaces has not necessitated any radical change in the original electrical scheme as a whole. Such improvements as have been made have been rather in the nature of refinement than essential change. In the case of the large electric furnaces, it is more necessary than

are complete as determined by the careful testing of the slag and metal, the current is reduced until a proper pouring temperature is obtained.

### PYROMETRIC CONTROL OF TEMPERATURES

The pouring of steel from the electric furnace is subject at all times to the careful control of pyrometric observation. For the production of a satisfactory steel, a proper casting temperature is an important element in all processes, but with the electric furnace special care is needed, partially because of the high heats obtainable with the electric arc. Electric steel on account of its freedom from gases is specifically a dense steel, and in metal of this character the pipe tends to be exaggerated. It is our custom to teem all electric steel in inverted molds with refractory hot tops. As a result, little difficulty is encountered either with the piping as usually found in the ordinary ingot.

As to alloy steels, it is very necessary to guard against any condition that will unduly tend to unequal ingot strains and special precautions are taken to avoid undue surface tension in the molds. We are now cast-

ing ingots weighing from 3,400 lb. to 38,000 lb., the uniform solidification of which is made the subject of the greatest care. Top pouring, box pouring and bottom pouring are resorted to, as the individual character of the steel best appears to warrant, and the entraining and inclusion of slag or other foreign matter is carefully guarded against.

To one familiar merely with the casting methods in vogue with ordinary openhearth or Bessemer steel, the pit practice incident to the proper manufacture of electric steel is something of a revelation. In the subsequent work to which the ingot is subjected, whether in the forge or in the rolling mill, special precautions are taken in the heating, in the reduction of the metal and in the cooling of the product. Ordinary mill practice will by no means suffice if proper results are to be obtained, especially when alloy steels are concerned. Steel which may be innately of the highest quality when tapped in the ladle may readily retrograde or become unfit unless there is exercised extreme care in its later manipulation. Quality is peculiarly the *sine qua non* of electric steel and the price of success is eternal vigilance. There is of course nothing occult nor mysterious in the electric method, although there is more or less misconception concerning the production of electric steel. The electric furnace when used for the manufacture of steel may be likened to a large crucible heated from within instead of from without by the electric arc. It is capable of performing not only the functions of the openhearth but very largely those of the crucible as well. Its superiority lies in the rare purity of the heat derived from the electric current and in the peculiar slag control that can be commanded in a neutral atmosphere.

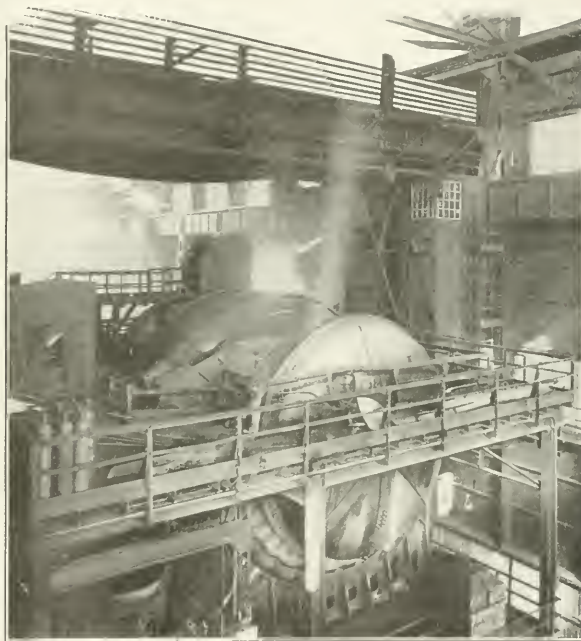
#### SUPERIORITY OF ELECTRIC STEEL

Both the Bessemer and the openhearth processes are distinct in their physical and metallurgical character. The electric process may likewise be considered as distinct when concerned with the manufacture of steel directly from cold metal. When, however, it is used to finish metal which previously has been made in the Bessemer or openhearth, it may be considered as supplementary to standard methods rather than as

an independent process. Other than as manufactured in the smaller and perhaps more ephemeral installations, electric steel is to-day, and probably will be in the future, largely produced by a duplex or triplex process whereby, strictly speaking, steel is electrically refined rather than electrically made.

#### FUTURE METALLURGY OF STEEL

And now a word as to the future: I am not unmindful that "a prophet is not without honor save in his own country." Moreover, human limitation and the kaleidoscopic changes of the past make one hesitate to forecast the metallurgy of steel. While ours is the age of steel, it has been given to men here present to see the passing of the age of iron. The crucible is hoary in its antiquity. The converter a short generation ago was but a conception in the mind of a man whom many of us know personally and the openhearth as an essential factor is even more striking in its adolescence. It behooves one, therefore, to be conservative in his prognostication. Forty years ago this country produced but little over a half million tons of steel, 90 per cent of which was made by the Bessemer process. Last year we made 43,000,000 tons of steel, and to the openhearth 75 per cent is to be accredited. While our production of Bessemer steel has remained nearly stationary since 1906, when it reached its zenith



POURING PIG IRON INTO THE 1300-TON MIXER AT THE ILLINOIS STEEL CO.'S TRIPLEXING PLANT

with an output of 12,250,000 tons, the openhearth has rapidly forged ahead, and last year it accomplished over 32,000,000 tons.

The marvelous development in Bessemer steel was due both to its superiority for general purposes as compared with wrought iron and to its relative cheapness of production. The more recent expansion of openhearth is attributable, not alone to changing ore conditions and to the lower cost incident to modern construction, but to the increasing demand for a higher quality of steel. The passing of the Bessemer plate and the Bessemer beam and channel was only a prelude to the replacement of the Bessemer rail by its openhearth rival. It is true that steel made by the Bessemer process is admirably adapted to certain products and for many years to come will play an important part in the metallurgical economies of our nation, but the glory

of the converter has definitely paled before the more enduring reliability of the openhearth. In the earlier stages of our steel manufacture, tonnage, as an essential element of cost, was a dominant consideration. Neither the mill nor the consumer attempted more than a general differentiation as to the character of the product. It was largely a matter of quantity and price. Now quality stands first and, while tonnage has gone on apace, volume has become more and more subordinate to character of production.

What does this increasing demand for higher quality portend for electric steel? How much is history to repeat itself in connection with the new process? It is clear that the lower the cost of production, the greater will be the field presented, and much will depend upon the ironmaster's ability to reduce the cost of electric refining to a minimum. When we realize the economies that have been commanded with the openhearth furnace during the last 20 years, it perhaps is not unreasonable to anticipate that much may be accomplished along similar lines with the electric furnace.

#### FUTURE INCREASE IN PRODUCTION OF ELECTRIC STEEL

If one is intelligently to read the future, he must take into consideration both statistics and psychology. The annual statistical report of the American Iron and Steel Institute first separately classified electric steel in 1909, with a production of 13,762 tons. Last year this country produced 234,000 tons, which is more steel than was made annually in all our openhearth furnaces 30 years ago. The output of electric steel this year undoubtedly will be much greater. We are now producing at the South Chicago plant at the rate of 140,000 tons per year, and we shall shortly be producing at the rate of 200,000 tons per year. Our country is growing rapidly, and the per capita consumption of steel is growing even more rapidly. In 1900, our population was approximately 76,000,000, and each of our inhabitants represented an annual consumption of 280 lb. of steel. In 1916, our population had reached 103,000,000, and our annual consumption of steel had increased nearly three-fold, to 820 lb. per capita. These figures do not include our exports of nearly 5,250,000 tons made that year. So much for statistics.

As for psychology, we should not forget that the luxury of today is the necessity of tomorrow, and that emulation is a powerful creative force. Bessemer steel was eminently satisfactory until the superior quality of openhearth metal relegated it to a subordinate class. And now comes electric steel with a still higher standard. Safety cannot be measured by price and public opinion will more and more insistently call for the highest excellence in the automobile, the airplane and other forms of fabricated material.

Forty years ago Sir Williams Siemens dreamed of making electricity the handmaiden of the metallurgical art, and through his efforts his dream was realized in the birth of electrometallurgy. Twenty years later, Heroult visualized the dominance of electrometallurgy in the realm of steel. Whatever the future may have in store, let us remember that progress waits upon vision, and vision, even though it resolves for the moment into a mirage of shattered hope, often is ultimately translated into accomplishment.

## Research Preparedness in the Zinc Industry

BY PARKER C. CHOATE

**A**CTION and reaction are equal but opposite. The nearly stimulation of spelter production by the war has caused over-production with a consequent drop in prices to the point where no material profit accrues to the distiller. This condition of affairs will soon be followed by sharp competition and the survival of the fittest, in other words, of those who possess the cheapest mineral values coupled with the cheapest method of extracting the maximum metal contents. Since zinc is perhaps the most prevalent of all metals except iron and aluminium in the minerals contained in ore bodies, the coming struggle involves the technical efficiency of the metallurgical process or the economical treatment of the complex ores of zinc rather than the procurement of the selected grades of concentrates.

In the following matter I will describe the general metallurgical present and future, as it appears to me, using broad lines of comparison, showing the commercial relations and the forces that will bring the radical changes for those who live by the zinc industry. Briefly, we must create the art of volatile concentration. We must briquet all retort charges, and proper briquetting involves pre-reduction and coking. We must adopt the vertical retort. We must make the gas as a costless by-product fuel. We must extract the lead, silver, and other valuable metals from the raw sulphide by leach electrolysis. This done, with the associated acts, we are led to a much cheaper operating cost, a better extraction, an easier labor problem, and an indifference to the relative metallurgical complexity of the zinc concentrate handled.

I do not aim to give details of operation, which however are largely at hand; on the other hand I will not picture any act or result that is not obvious through tests, by analogy, or by known metallurgical science. I can merely point the way in such a brief outline, but can submit details of practically all the statements, admitting that much is novel in either degree or principle.

It will be a great benefit if this radical picture brings out a full discussion. Such is needed for the well-being of the art, since no branch of metallurgy is in more need of advance.

#### PROCESSES NOW IN USE

At present we are using retort distillation just as it was forty years ago. Acid manufacture was introduced as a necessity, while the volatile treatment of residues is unsound since they should have no value to extract.

The volatile practice is antiquated. Recently there have been several attempts to distill zinc in an electric furnace, none of which survive because of expense and inefficiency. However, there will probably appear a radically different process of electric smelting which will survive. It will be operated at the mines, without roasting the ore, and will save in one act over 90 per cent of the zinc, lead and silver as metals. The saving on freight charges and in expensive reduction plants is obvious.

Under the stimulation of war prices for chemically pure zinc a successful process of refining spelter by electrolysis has been established, analogous to the well known electrolytic refining of copper. This industry is



very creditable and perhaps profitable for a time, but its only future would appear to be in connection with the electric smelting described, which may produce a spelter carrying lead and silver as by-products.

We have also several examples of leach electrolysis using so-called insoluble anodes, the solutions being prepared by leaching roasted ore or a zinc-lead-silver fume. Leach electrolysis is with us to stay because up to a certain quantity the almost pure zinc will command the market. Furthermore, it is a very attractive process in the hands of mine owners who also have cheap water power and who now look upon the zinc content of the ore as a liability rather than as an asset.

In my opinion, the leaching of fume is the cheaper of the two methods when volatile concentration is efficiently practiced. In passing it might be mentioned that a true insoluble anode does not exist, and perhaps never will, due to the great destructive action of electric dissolution.

#### VOLATILE CONCENTRATION

Experiment shows that the art of volatile concentration gives a heat balance comparable to that of the usual boiler practice, the heat being conserved by a special design of flash boiler and hot-blast stove. The boiler and stove are to be made of prepared tubes which resist oxidation up to 800 or 1000 deg. C., and have entirely vertical surfaces automatically cleaned of dust. Since the blast is to be heated to a temperature above the ignition point of the fuel bed, it is obvious that no wet-tube water-circulating boiler can be used, because the boiling point of water is about one-half the ignition point of coal.

The fume is to be precipitated by electrostatic action from cooled gases. A mechanical bag-filter may finish cleaning the gases of the last fraction, as this work is difficult under electrostatic action.

Special stokers built on lines used in coal burning are to be used to charge the mix into the retorts. The admixed fuel may be reduced to 15 or 20 per cent of that now used, and if credited with the heat conserved in steam as power, may be under 10 per cent.

Zinc carbonates, silicates, residues, and low-grade raw sulphides may thus be heavily concentrated with high extraction of silver, lead and zinc at nominal labor and fuel costs. The conditions described above constitute a new art as compared to any existing practice.

#### LEAD AND SILVER EXTRACTION

I would propose to reverse the usual practice and extract over 90 per cent of the lead and silver values together with a large proportion of iron, if so desired, from the raw concentrates before decomposing the zinc blende, by a process of electrolyzed leaching. The solvent will be regenerated, and the power costs confined to the current necessary for deposition of the small weight of lead, silver, copper, etc., that is electrolyzed. This step may pass to the mine operator as an adjunct to flotation, rendering the most complex ores metallurgically as simple to the zinc smelter as the best Missouri blende. This process will perhaps be cheaper and doubtless much more efficient than the smelting of residues.

#### SULPHURIC ACID

I see little value to the zinc distiller in making acid. When he realizes the trouble he avoids and the benefits he gains from distillation of raw sulphides the practice

of acid making will cease. He may more profitably make the metalloid sulphur from the calcium sulphide residue, as it has ready sale and moderate freight charges to market. However, manufacture of acid may precede or follow distillation. It may be made from the sulphur extracted from the calcium sulphide residue or it may be omitted altogether with no sulphur smoke nuisance.

#### BRIQUETTING

The briquetting of the entire retort-mix is a coming necessity, whatever the distilling practice. Good briquetting practice uses 6 per cent pitch as a binder, a compression of from 2000 to 5000 pounds per cubic inch, followed by coking at 400 deg. C. (or up to 800 deg. C. if cadmium and lighter impurities are to be removed). Caustic lime in the briquet requires special knowledge or hydration will take place during handling. Properly made briquets cost about \$1.00 per ton, including pitch and baking, are almost as hard as natural ore, conduct heat twice as well as the usual mix, and, if lime is used, reduce the zinc in residues to one per cent irrespective of the complexity of the ore, avoiding slagging action on the retort at the same time. Because of ideal contact reactions due to fine grinding and mixing, briquets use only about 25 per cent of the carbon in the usual mix. Their use also reduces the iron that usually passes to the spelter mechanically. Briquets should not be over  $\frac{1}{2}$  inch in cross section.

#### FUEL GAS AND CARBON MIX

The best carbon for retort mix is the pulverous residue from low-temperature retorting of non-coking or lignite coals. This carbon is economically produced from local coal slack. Since it supplies valuable by-products of distillation such as tar and tar oils for flotation as well as a large excess of its own gas of distillation, that carbon used in the retort mix will be produced at no cost. As will be shown later, the entire fuel gas required for distillation of the zinc may also be a costless by-product of the manufacture of domestic briquets.

If we assume that it usually requires 125,000 cubic feet of natural gas to distill one ton of spelter, it may be assumed that recuperation of waste heat will reduce this to 75,000 cubic feet. If, now, we use the lime-briquet charge in the retort, it has been shown that one-half this fuel is saved by reducing the time and temperature of distillation. It is then practicable to use no more than 40,000 cubic feet of natural gas to produce one ton of spelter.

One ton of Illinois coal will produce 7500 cubic feet of excess gas, net, of about three-fourths the calorific power of natural gas, together with about 1500 pounds of carbon residue and a quantity of valuable by-products more than capable of paying for the cost of retorting. The briquetted residue will sell as domestic fuel for more than the cost of the coal and freight bills. The residue produced from low temperature distillation contains some undistilled hydrocarbons, makes the ideal retort mix, and briquets properly into an ideal domestic fuel in a section of country devoid of such.

If in a briquetted retort-mix with roasted or raw ore we use one to two pounds of carbon per pound of spelter produced, we may calculate: For one ton of spelter we must manufacture 50,000 cubic feet of gas of 600 to 700 B.t.u., from about 6 or 7 tons of slack coal, producing

at the same time 3.75 to 4.5 tons of carbon residue with the usual tarry by-products. We use in our mix up to two tons of carbon per ton of spelter produced, and consequently sell 2.5 to 3 tons of briquets and other by-products at a material profit.

#### RETORT FURNACES AND DISTILLATION PRACTICE

The labor problem in present distillation practice is serious and expensive. It is obvious that the use of vertical retorts will cut labor bills heavily and reduce the amount of specialized labor necessary. It will further reduce retort costs, since more enduring retorts can be made up to 20 inches in diameter. A dead-core retort can be provided giving a larger ratio of volume to circumference with no greater depth of heat penetration than in the present practice. Vertical retorting can also be made continuous, as has already been done.

I believe that the briquet made with raw ore and burned lime is the charge of the future. The virtues of this mix will gradually be appreciated by operators after actual practice. Should the distiller desire to continue roasting, he may do so and hold his residues down to one per cent of zinc, irrespective of the degree of roast, by using under ten per cent of lime. However, the raw-ore briquet is the better heat conductor, acts better in the retort, and requires the lower temperature for the reaction. If there is any real value in the sulphur content of the ore it would seem best to reclaim it from the calcium sulphide residue.

The firing of retorts should be by small gas jets. Pulverized coal will be found a most efficient auxiliary and can be introduced through the same jet system. I can see no future for the large single-flame burner. Pulverized coal firing is well established, offers large savings and economies over producer practice, and produces heats much better under control. It is practiced best with the dead coals or carbon residues and involves the same principles of draft and pressure as gas firing, while the fine ash produced by powdered coal is understood and handled better than the slags formed in producer-gas firing. In special locations the combined use of retort gas and pulverized carbon may be the most economical, but not where a civic population can consume a domestic briquet in quantity.

Recuperation of waste heat can now be performed in specially prepared iron pipes which easily withstand oxidation up to 800 to 1000 deg. C., and even more for a limited time. This item materially affects plans for conservation of heat.

#### QUALITY OF SPELTER

If we remove lead by leaching concentrates, none will enter the spelter. The same may be said of the iron; but in this case, the lime briquet permits only small quantities of iron to pass over into the spelter mechanically, the amount not increasing even in the third draw of metal, even with concentrates up to 10 per cent of iron.

Cadmium, together with other lighter impurities, may be largely removed in coking the briquet, simply by raising the temperature to about 800 deg. Centigrade.

#### ECONOMIC FORCES

Past practice will be abandoned for that which will produce a cheaper metal, owing to the over-stimulation

in production and the existence of other methods than zinc distillation, but more especially to the demands of labor and the increased cost of coal. Thus the forces of necessity will soon make technical efficiency the dominating factor among zinc distillers. It will no doubt be difficult to abandon large investments in furnace equipment, and many directorates will be incapable of seeing the necessity of so doing, but those who do not will be forced to give way to those who do. The economic forces must rule. Conservation is the root of economy, and the dominant factors in this instance are fuel and labor.

#### CONCLUSIONS AND COMMENTS

In reviewing the subject, perhaps I see the more merit in the fume-leach-electrolysis idea because I invented and practiced it twenty-five years ago; but today I see the chances for improvements in volatile concentration and the possibilities in the use of a composition anode.

I am satisfied that the small electric smelter will find a place in the hands of the mine operator, there being by-products in metals to save and freights to reduce. The removal of lead and silver prior to distillation will materially enhance the value of the complex zinc ores to the mine operators.

The greater changes are necessary in distillation practice, and their economies are obvious. They must offset the heavy freight bills by materially raising the extraction and by the conservation of heat and labor. Research shows that briqueting will solve the domestic fuel question for the Middle West, since the distillers have a use for the gas, while the domestic consumer will be provided with a fuel fully equal to anthracite at a lower cost.

There would appear to be no larger public service of lasting kind than the double act of giving the West an ideal economical fuel made from their local non-coking coals and lignites, and placing the zinc distillers on a firm basis to meet the impending competition with leach electrolysis and electric retorting processes.

Today the Western public largely loses the volatiles of their local coals in their commodity use, with the simultaneous production of a smoke nuisance. If the local coals are carbonized and briqueted as is already practiced in a small way, there is difficulty in selling the excess gas produced. The zinc distiller must use gas, but if he uses producer gas, he does so only at a great sacrifice, since it has a low calorific intensity and no by-products are saved. The economies accruing with low-temperature carbonization aggregate large figures.

Definite experimentation will be along radical departures, but for that matter, so was the flotation process. A working unit of industrial size alone can show the economies. "Seeing is believing" to the business mind, no matter how clearly the engineer makes his figures and deductions.

Following the lines of conservation, why would it not be good business for several large interests to join in this radical research? In this manner the inevitable duplication and the patent war could be avoided. The zinc distillers centered in a thickly settled community in the Middle West can do the community a large service at a profit to themselves under the research outlined above.

Essex, Mass.

## The Rubber Embargo

### Economic Effects of Reduced Rubber Supply— Reclaiming Old Stock—Guayule as a Local Source of Natural Substitute

BY ANDREW H. KING

SOMETHING over a year ago the writer published a series of three papers dealing with the crude rubber situation, and pointed out as a matter of national preparedness that our country should be, at least in some measure, independent of foreign sources of supply. The incentive which led to these papers was the spectacle of a modern nation suddenly deprived of its supply of crude rubber. We know absolutely that the blockade has touched a very vital spot in the German armor. If kept tight enough and the war lasts sufficiently long, the absence of rubber may ultimately become one of the straws which will break the camel's back. One very pertinent instance may be cited. The Allies now have one of the most elaborate systems of gas defense that can be devised. Every man and every animal liable to gas attack has his gas mask. These masks are quite effective and give absolute protection against all of the gases as yet used by the Huns. They consist primarily of rubberized fabric. The Germans have no rubber so make their masks out of leather. As a consequence they are stiff, hard to put on, and do not fit well. Allied gas attacks are in many instances successful because of the length of time required to adjust the enemy mask.

#### TRANSFER OF SHIPPING CURTAILS CRUDE SUPPLIES

Little did the writer, or any one else for that matter, imagine that there was any immediate danger of even a curtailment of our crude rubber supply. We thought it something worth thinking about for the future, but no one dreamed that such a situation would develop so quickly. The possibility of a hostile fleet blockading our shores was then, and is still, remote; but the contingency which very few if any of us realized was the great efforts which we were to make on entering the war. Those who are in a position to know say that the greatest trouble has been to make the American people realize what an enormous responsibility rests upon them. The war on barbarism is not to be a side issue nor any sort of a picnic. We are in this thing and for the sake of posterity we must not lose. Our effort must be that of a whole united people. The ultimate decision rests largely upon the American public. We hold the balance of power. If we get into the harness as efficiently and as completely as the French and British, there can be no question of the outcome. There is every evidence that we will equal if not exceed our allied friends in this business of war. The progress which has been made in the first year has been really remarkable. There has been very little grandstand playing and hip-hurrahing, but the wheels have been made and fitted together. Now they are beginning to turn. While all that has been done is due primarily to the spirit of the people, yet no small credit must be given those who by helpful criticism sought to correct evils and mistakes of management.

The present situation on the Western front is an

extremely critical one. Germany has already tried out the mettle of American soldiers and has found it better than her most pessimistic observers ever had the nerve to admit. She is well aware of the great organization now getting into low gear and she knows perfectly well that such a steam roller will finish her dreams of world conquest when it gets properly working. Her only hope for victory is to defeat the French and British before our strength becomes a deciding factor. This is the reason for the spring offensive. If Hindenburg can break the allied armies within the next six months regardless of what it costs him in lives or in money, Germany will win. Such a calamity is not impossible. In fact, the chances are almost fifty-fifty now. Our brave allies must bear for just a little longer the combined might of the German war machine. So it becomes imperative that American soldiers be sent to France just as fast as sufficient ships can be furnished for their transportation and to keep them supplied. The slogan "Ships will win the war" is absolutely true. The submarine warfare of the enemy, while not successful, has made a great dent in the world's shipping. Because of this emergency ships are being withdrawn from all possible peaceful pursuits, and we are brought face to face with a new paradox, a blockade of ourselves by ourselves in the interest of national safety and world progress. There are not yet sufficient ships to handle normal commerce and to transport the troops with their supplies. When our shipbuilding program gets under way this condition ought to be considerably bettered, but for the time being peaceful trade must suffer.

The situation is, of course, not nearly as serious as an enemy blockade but the curtailment of raw material will be keenly felt not only in the rubber industry but others as well. In the matter of shipping, rubber is rather a serious offender since such a large space is required to carry comparatively a small weight, and the distances to be traversed are so enormous. The specific gravity of rubber is about .93. Its weight per cubic foot is 58.1 lb. So to transport a ton (2000 lb.) of rubber the very least space required would be 34.4 cu.ft. As a matter of fact the actual space necessary is about 20% greater, making it about 41 cu.ft. America imported last year about 157,000 tons of rubber. The cargo space occupied was approximately 6,500,000 cu.ft.

#### SOURCES OF OUR RUBBER

Much of our rubber comes from the far East. In 1916 only 23% of the 116,477 tons consumed was imported from South or Central America. Most of the 77% remaining (very little comes from Africa now) was plantation rubber from the Far East. The distances are tremendous. Singapore, which is located on the tip of the Malay Peninsula, Federated Malay States, is probably the most important marketing place for crude rubber in the world. The old route now closed because of submarine activity in the Mediterranean was by way of the Red Sea, Suez Canal, Mediterranean, London, and thence to New York. The distance is 12,900 miles. This made London the neck through which nearly all the crude rubber in the East had to pass. The new route is by way of Honk Kong, Yokohama, Honolulu, to San Francisco or Seattle, and thence by



rail to Akron or New York. Singapore is 8460 miles from San Francisco, which is approximately 3000 miles by rail from New York, making a total of 11,460 miles. An all water journey from Singapore to New York by way of the Panama Canal is 11,760 miles long. By way of comparison, the port of Para in Brazil is 2600 miles from New York. During the past two years a constantly increasing tonnage has been shipped direct from the far East to our Pacific ports. It requires no stretch of the imagination to see that a great deal of shipping is required to supply us with crude rubber. Any curtailment in this supply will set free a respectable number of first-class freighters which are badly needed for the troops.

This is exactly what the Federal War Trade Board wishes to do. There is no desire to work undue hardship to the industry and as a consequence the first plan proposed, which will be in operation before this is published, is to be effective for only three months, after which the working will be reviewed and such modifications as are necessary will be made. The plan is as follows:

During 1918 there are to be only 100,000 tons of crude rubber imported, which figure is 57,000 tons less than the official estimate for 1917. The 100,000 tons includes a quantity of 35,000 tons which the government reserves for strictly war purposes. This rubber will be used in gas masks, balloons, truck tires, auto tires, proofing, etc., and the figure is none too high. This leaves only 65,000 tons to take care of normal peace time activity. The official figures for net consumption for the past five years are as follows:

|         |                                            |
|---------|--------------------------------------------|
| 1913... | 49,850 tons                                |
| 1914... | 61,251 tons                                |
| 1915... | 96,794 tons                                |
| 1916... | 116,477 tons                               |
| 1917... | 157,000 tons (About 170,000 tons imported) |

During 1918 there will doubtless be quite a decrease in demand for rubber goods for civilian purposes, but even on the basis of 1916, which will probably be about right, our rubber factories will face a shortage of 51,500 tons. In other words, the supply of crude rubber for ordinary purposes is to be cut in half.

Rubber on hand or in transit is not affected. The large companies have on hand from four to six months' supply. A department with which manufacturers may deal directly in importing rubber has been established by the Trade Board in Washington for the period of the war. Crude rubber can only be imported by obtaining licenses from this department and guaranteeing that the amount purchased is within the restricted quantity fixed by the government. Prices have already been fixed, varying from 62 to 68 cents per pound, depending on the grade of rubber imported. Prices on manufactured articles have not yet been fixed but probably will be if there is any tendency towards inflation.

In certain quarters there is a disposition to meet the new turn of affairs with an optimistic feeling that three months will see the end of the embargo, that after this time ships can again be spared and that the government will see the fallacy of throwing thousands of men and women out of work, etc. Such an attitude shows a woeful lack of foresight. Within three months the large companies will doubtless be

swung over to meet the new conditions. No one gauged correctly the huge effort that America would make in the war. The first plans were for an army of 2,000,000 men. Now it is proposed to put an army of 10,000,000 men in France. The demand for shipping will increase rather than decrease and the present curtailment will likely prove to be only the first pinch. Within three months we may be asked to take a further 50% reduction, and it is not impossible that within a year we may be importing only enough rubber for war needs. This does not by any means sound the death knell of the American rubber industry. The men directing it are big enough and resourceful enough to weather through. The fate of the small companies, poorly financed and without extensive organizations, is more doubtful. There may even be several failures.

#### OUR INDUSTRIES ARE OUR EFFECTIVE RESOURCES

There is another angle to the situation which may well be given a brief mention here. On all sides we hear slogans—that food, ships, etc. will win the war. All these are merely incidentals. There are but two fundamental necessities—Spirit and Money. The first



THREE YEAR, TWO YEAR, ONE YEAR  
GROWTH OF GUAYULE OR GRAND CUT-OVER

we have in large measure and need not be further discussed. The second we have also, but its application is a little different. The huge and heretofore unheard of sums of money spent every day by the opposing armies are understood by all as well as our powers of imagination permit. Such a stream of gold is required to feed the war machines that it would be well to look at the source. All money is the fruit of business and the product of industry. We must keep the source of money in good condition.

There are two ways of paying for the war: One is to tighten the belt a few notches and take it out of savings. This excellent idea is embodied in thrift stamps and in the bank plan for Liberty bonds. The other is to make the money by extensive trading with

neutral countries, selling them more than they sell us. This last is all very well provided there are any neutrals and they have the money to purchase with. Our greatest markets are now South America and perhaps China, in both of which extensive selling campaigns should be carried on and for which efforts to give passable steamboat connections should be made. Manufacturing for home consumption will be limited more and more to those things which are essential and non-essentials will go by the board. But for export to neutrals we should make everything there is any demand for, whether it is essential or non-essential.

About 70% of the crude rubber imported goes into automobile tires. The tire is part and parcel to the automobile whose only purpose is transportation. The machine can no longer be looked upon solely as a pleasure car, i.e., a non-essential. By far the larger portion of American automobiles are real necessities. They are the best antidote for the tendency of modern men and women to crowd into large cities and bring about undue congestion. They are now as firmly woven into our national life as the horse was 30 years ago. Auto tires are essentials and should be considered as such. Consequently their manufacture for certain purposes should not be reduced to the point where it will work a hardship to the car owner. The service of truck tires needs no comment. They are just as important to the army behind the line as to the soldiers in the field.

The position of the rubber manufacturer is unique. For patriotic reasons he must import as small a quantity of crude rubber as possible and for other equally patriotic reasons he must keep his countrymen supplied with all rubber products which are essential. But what may he use in place of crude rubber? Synthetic rubber is not a commercial possibility. With the advances which have been made in rubber tree cultivation such an industry is now impractical. There are only two solutions, both of which are required. They are shoddy and guayule.

#### SHODDY

By shoddy we mean reclaimed rubber. The methods of reclaiming were discussed by the writer in a previous paper (this *Jour.*, Mar. 15, 1916, p. 310). The most satisfactory and most generally applied process is that of A. H. Marks, U. S. 635,141 Oct 17, 1899, which has now expired. This procedure consists essentially of digesting finely ground waste in a 3% sodium hydroxide solution at 125 lb. of steam (344° F.), with stirring for 24 hrs. more or less as required.

Many factories have their own reclaiming plants and there are numerous firms which make it their sole business. The machinery for extensive production of shoddy is at hand and will doubtless be used to the limit of capacity. A better organization among the scrap dealers would be desirable as would be a better co-operation between the consumers of rubber goods and the scrap gatherers. The public should be instructed as to the importance of the smallest piece of scrap rubber, and all worn out articles should find their way to the reclaiming plants.

But the reclaiming plants cannot produce a shoddy the equal of crude rubber. Germany has had to de-

pend upon them alone and we know how she has failed. The quality of her rubber goods has declined to the vanishing point. The function of reclaimed rubber is merely to stretch the crude rubber supply and not to replace it entirely.

#### GUAYULE

The real load will ultimately fall on guayule, which can be imported from Mexico by rail. During the past six years the harvesting of guayule has been greatly retarded by the unsettled condition of Mexico's internal affairs. Happily things now seem to be improving. Some one has evidently spoken a soft word to Carranza and the German agents appear to have cast Villa adrift. Mexican guayule is now being placed on the market by at least two large corporations.

In the years before the revolution Mexico annually produced about 10,000 tons of guayule. The decline began in 1911, by 1912 it was only 3500 tons, in 1914 but 728 tons. 1915 saw an increase, the production



GUAYULE SHRUB.

amounting to 2555 tons. For the twelve months ending June, 1916, was 1408 tons.

In the above I have stated that the action of the War Trade Board has created a shortage of over 50,000 tons of rubber. The all important question now is—can this deficit be made up with guayule? Endlich estimated that up to 1909, 225,000 tons of shrub had been harvested, which was about half the supply originally available. By best methods of treatment the shrub yields 9.5% rubber, based on the dried weight. If Endlich's estimate were true there must have been only 22,500 tons of rubber available in 1909. But Mexico has exported since then something like 30,000 tons of guayule, so it must be concluded that he was entirely too conservative. To estimate with any degree of accuracy the shrub content of such a large area is almost impossible owing to the irregular nature of the separate groups.

Since 1912 there has been but very little harvesting in the great Chihuahuan district. Since 1910 more care had been taken in gathering the plants. They were not ripped out root and all as in the old days, but were neatly cut off at the ground. This left the root system intact, so that it would send up shoots which could branch out and produce a bush at least 16 inches high in five years. Fifteen years is required for guayule to grow from seed to maturity in the desert. There ought to be great quantities of new

plants available, to say nothing of those which must have grown from the roots of plants previously cut. It is now six years since the Mexican trouble started. A very safe estimate of the shrub now available may be placed at 500,000 tons, which when harvested should yield about 50,000 tons of rubber.

This takes no account of the rubber produced by our own Southwest. In 1911 there were 6,000,000 acres of guayule growing wild in Texas which is in the same belt as the great Chihuahuan desert. There is also the factor of cultivated guayule which will soon be of considerable importance. The International Rubber Company now has rather a large plantation near Pacheco, Arizona. This is being gradually increased. It is said that the present extent is near 10,000 acres. This company is said to be backed by the Standard Oil Company, and has a capitalization of \$29,000,000. It still controls a number of large plantations in Mexico.

#### PRODUCTION INCREASED BY INTENSIVE IRRIGATION METHODS

DeKalb claims that in California guayule under irrigation has been known to produce as much as 28% of its net dry weight in rubber. He also states that by four year intensive irrigation methods 25 tons of the dry plant may be grown per acre. The best scheme is to irrigate with plenty of water until the plants become sufficiently large and sturdy. The water is then shut off for six or eight months, during which the plant produces rubber in the tissues. At the end of this time irrigation is resumed and is continued till a new growth takes place, after which the water is once more shut off. This procedure is repeated until four years have expired, when the plant is ready for harvest.

The proposition of guayule plantations is one which has been neglected long enough. It is time for American business to get behind it and to push it along. Such an industry would be a financial success, paying it is conservatively estimated 8% without irrigation, or \$180 per acre per year on irrigated land.

#### OBSTACLES IN WAY OF USE

To swing over completely to guayule from plantation rubber would now be quite a hard task since it has been out of the field so long. There are now not many of the old compounders left who handled it in the days when it made up about half the crude rubber used in the country. Employed alone without treatment it is not satisfactory for high grade stocks. However, it can be blended with plantation rubber (Hevea) with reasonably good results. If one is to get the value out of guayule it must be deresinated. It contains approximately 25% resin, which behaves somewhat like so much oil and has a dissolving and softening action on the rubber. This comes into play during vulcanization and later when the article is in service. The extracted resin may be disposed of by milling it with dry shoddies, on which it has rather a beneficial effect.

There were in this country at one time about fifty deresinating plants, nearly all of which have now been dismantled or turned to some other purpose. Before the country can again make use of guayule to the best advantage new plants must be built and perhaps new procedure adopted.

### Plans for Preferential Fuel Distribution

Plans for the distribution of coal within the various states have been formulated and put into operation by the United States Fuel Administration. This plan is designed to define the responsibility and authority vested in the State Fuel Administrators for the distribution of the coal allotted to their respective states, subject to general instructions issued from time to time from Washington.

The War Industries Board will decide what consumers shall have preference in securing coal; but the United States Fuel Administration has been asked to assist in the compilation of complete preference lists of obtaining reports and recommendations on individual firms from the State and Local Fuel Administrators.

The crux of the new distribution plan lies in the compilation of these preference lists. All consumers of coal, except domestic consumers, will be recorded under the following classifications:

- (a) Railroads,
- (b) Army and Navy, together with other Departments of the Federal Government.
- (c) State and County Departments and Institutions,
- (d) Public utilities,
- (e) Retail dealers,
- (f) Manufacturing plants on War Industries Board's preference list,
- (g) Manufacturing plants not on War Industries Board's preference list.

The first six classes will be given preference in coal shipments in co-operation with the plants of the War Industries Board.

The distribution of coal to consumers in the first two classes will be handled from Washington. Washington will also supervise shipments to a few vitally important plants.

The list of consumers entitled to preference as established by the War Industries Board will be obtained through a questionnaire sent to every manufacturing plant in the country using more than 500 tons of coal annually. This list, when compiled, will be furnished to each Fuel Administration District Representative in the producing fields which supply the various states; and with these lists to guide them, together with weekly reports which will be required from each manufacturing plant, the State and Local Fuel Administrators and District Representatives will give their particular attention to building up proper stocks of coal at all essential war plants.

In order to control the distribution of coal to domestic consumers and industrial plants by retail dealers, the dealers will be required to make a special report to the State Fuel Administrators and from these reports deliveries to manufacturing plants not on preference list can be curtailed when necessary.

Under this plan of distribution each consumer should arrange for shipments from the same source of supply as last year, if possible. If diversion of coal for the war program, or the zoning system will not permit this, the consumer should make every effort to form new connections, preferably under a contract arrangement, wherever a supply is available, before calling on the State Fuel Administration.



# Prospects of a Chemical Industry in Southern California\*

The Possibilities of the Development of the Deposits of Lignite and Desert Alkali into Sources for the Production of the Fundamental Chemicals

By JULIUS KOEBIG

IN DISCUSSING the prospects of a chemical industry, it is essential to define the scope of the term. We have many smaller and larger plants on the Coast which we call chemical factories and of which we are accustomed to boast at home and abroad, but we have only a few whose name and importance are more than of local interest. The principal exceptions are in the manufacture of sulphuric acid, super-phosphates, explosives, soap, Portland cement, beet sugar, leather, and the refining of crude oil. They are in a flourishing condition wherever they are not unduly capitalized, and where the management expects to earn its profits from the earnings of the plant rather than from the manipulation of the capital stock. The basis of their success is:

(1) Abundance of suitable raw material at a cost comparing favorably with the cost of raw material in competing centers of the respective industries.

(2) Adequate local facilities for manufacturing and transportation.

(3) Home market for the product and opportunity to extend the market within a reasonable radius.

(4) Last, but not least, skillful management capable of modifying manufacturing methods according to local conditions and of improving constantly on such methods, both with regard to cost and quality of product.

Every one of the established plants, be they small or large, together with almost every industrial enterprise on the Coast, is at present under the disadvantage of the high cost of heavy chemicals. Many others are out of the question, because of this high cost of heavy chemicals. Without a home production of heavy chemicals, at prices not much higher than they can be produced in other centers of industrial activity, it is useless to expect the development of a chemical industry. This, however, demands large capital, enterprise and efficiency.

It is my purpose to place before you the possibilities in Southern California which justify the investment.

The vast chemical industries in Germany, France and England started from the manufacture of cheap soda, and still base their success on this product.

The manufacture of cheap soda is the very life blood of the rapidly increasing chemical industries of the East. Unless we are able to produce cheap soda, it is useless to try and build up a chemical industry.

Before closing these introductory remarks, permit me to give you some of my own personal experiences. When I was Assistant Professor of Chemistry at Strassburg, a gentleman called on me and asked if I would enter his employ for the purpose of developing an aniline dye-works. I told him that I had no experience in the manufacture of dyes. He replied that he wanted a chemist, the practical part would subsequently take care

of itself. When I resigned, after three years, we had over three hundred men in our employ; we had some fourteen chemists directing the work in the factory; I had a research laboratory in which from ten to twelve chemists were constantly at work on the development of new products and processes; and the factory paid from 80 to 250 per cent dividends each year.

On a trip across the Atlantic, I made the acquaintance of a gentleman heavily interested in an illuminating gas works in one of our largest cities. In discussing the possibility of utilizing his coal tar to better advantage than selling it at low prices for export, I advised him that the first step must necessarily be the erection of a tar refinery. He sent an engineer to England to copy the equipment of a prosperous tar refinery there. He bought, at high cost, the recipes used there, and hired a foreman in their service. He employed a chemist, not for running the factory, but for finding out whether there were differences in the guaranteed strength of acids, etc., which he bought. The refinery never was a success. After a few months an explosion occurred and the plant burned up. The typical differences between these two views is that of success and failure.

## THE NECESSITY OF INORGANIC INTERMEDIATES

The fundamental requirements for a successful development of a chemical industry are:

Cheap acids,  
Cheap soda,  
Cheap fuel and  
Cheap power,

to which has to be added cheap iron for machinery and apparatus.

Without these, and all of these, chemical works are doomed to remain of secondary importance. All they can hope to accomplish is the refining of half-finished products. The life of such industries, no matter how profitable they may be from the start, can only be a limited one. It is only a question of time before the consumer will learn to use the half finished product or to do his own refining, thereby cutting out the refiner's profit. One example will suffice to illustrate this fact. Establishments in this state, which carried the proud name of soda manufacturers, bought soda-ash and caustic soda in Europe or later on in the East. They produced sal soda and lye in small packages for the use of soap manufacturers and others, in addition to supplying the household trade. Some of these factories grew to considerable proportions. But today they are reduced to the level of retailers, while the consumers buy their supplies directly from the real manufacturers of soda.

These refiners, however, served a well-defined economical want in the early days of the development of our State. At that time the market for any kind of com-

\*Read before the Los Angeles Section of the American Chemical Society.

modity was small. We had few consumers of chemicals, or any other kind of merchandise for that matter, whose wants justified the purchase of needed supplies in lots sufficiently large to obtain reasonable freight rates. We then were tagged away in splendid isolation in the remotest corner of civilization. Our sturdy pioneers thought little of the cost of living and had less demand for manufactured articles. They had to and did employ their spendid energy and every available dollar at their command for the purpose of turning our state from almost half savagery into a fit place for human habitation and the pursuit of happiness. How well they have succeeded, we all know. In addition our railroads and the Panama Canal have changed our location from an isolated spot to almost the center of the coming commercial development, which is bound to have the countries bordering the Pacific as a stage. This shifting of the commercial situation, our large and rapidly increasing population, the development of our mines and agriculture, all make insistent demands for our industrial chemical development. Our mines need heavy chemicals for the reduction of their ores. Our fields and orchards need fertilizers for assuring their continued fertility. Our agricultural industries need chemicals again for manufacturing our agricultural products into staple articles. Our animal industry, our tanneries, our soap makers are handicapped on account of the high prices of chemicals. Our oil refiners offer a large market for soda products. These and many other industries already established offer an alluring market for the products of a general chemical industry, so that there can be no possible question of a market. This alone, however, is not sufficient. We must have the raw materials and manufacturing facilities required to secure a profitable production which will put us on a square, even footing with the centers of industrial activity now furnishing the products needed, so that we can rely upon our ability to retain our home markets for our home products against the keenest competition. It is my endeavor to show in how far our available raw materials justify us to advocate a general chemical industry under the local conditions.

In the manufacture of sulphuric acid we have already made a long step forward. Both the lead chamber and the contact processes are in successful operation on an even footing with other states and countries. Sulphur and pyrites are readily obtainable here. Our metallurgical works furnish us a never-ending supply of sulphur dioxide from their roasting furnaces, which is now mostly used in the production of by-product sulphuric acid. In conjunction with this sulphuric acid, muriatic and nitric acids could be manufactured; the former from our large salt deposits, and the latter from Chilean nitre, which is as economically obtainable here as in the East; however, we would be under great disadvantages at present, because our market for salt cake is very limited.

#### THE SODA INDUSTRY

In the alkali industry, conditions are decidedly different. At present, we have none. In order to ascertain whether such an industry is possible in Southern California, I must ask you to follow me in a short review of its history and its present status.

Perhaps the most epoch-making progress in the

chemical industry during the last 150 years was the Leblanc soda process. In England, where it found its first home and received its most essential development, it reduced the price of soda-crystals from \$300 per ton in 1814 to \$13 per ton in 1896. Its principle is a very simple one. In its first phase common salt is decomposed by the aid of sulphuric acid into sulphate of soda, commonly called salt-cake and hydrochloric acid. In its second phase the salt-cake is treated in the black-ash furnace with limestone and coal. The resulting black-ash consists essentially of sodium carbonate and insoluble calcium mono-sulphide. By leaching the soda is brought into solution. The remaining calcium sulphide forms the alkali maker's waste. As long as the factories were few and of small capacity, the muriatic acid was allowed to escape and the waste, a bad malodorous nuisance, was dumped into the ocean. But soon it became necessary to recover the muriatic acid and also to find some way of utilizing the waste. The one was accomplished largely by the manufacture of bleaching powder, the other by the ingenious chance process which recovers the sulphur and lime from the waste.

The second method for the manufacture of soda-ash is the Solvay ammonia-soda process. Its raw materials are salt-brine, ammonia and limestone. A properly proportioned mixture of salt-brine and ammonia is made which is treated with carbon dioxide. The bicarbonate of soda separates as crystals and is filtered dry. The filtrate contains ammonium chloride from which the ammonia is recovered by distillation of the limed mother liquid.

The third is the electrolytic process, in which the salt brine is decomposed by the electric current and chlorine gas and caustic soda produced.

Many other methods have been proposed. They, however, have either proven to be impractical or only of secondary importance like the manufacture of soda from cryolite.

The Leblanc process today has been almost entirely abandoned in favor of the ammonia process. The enormous factories in England and on the European continent have either gone out of existence or changed to the cheaper Solvay method. The reasons for such change are obvious. In the first place, it is necessary for the economical handling of the Leblanc process to combine under one roof the manufacture of sulphuric acid, sulphate of soda and the final black-ash, which requires an enormous outlay for first installation as compared with the Solvay or electrolytic processes. Then again it is much cheaper to produce and handle the large tonnage of salt in the form of brine than it can possibly be in the form of dry salt. And last but not least, the vast amount of muriatic acid, requiring heavy, expensive and costly apparatus for its recovery, does not find a ready and profitable market, either as acid or in the form of bleach.

#### SOURCE OF SODA FROM THE DESERT ALKALI

In considering the development of the alkali industry in California, we have therefore apparently only a choice between the Solvay and the electrolytic processes. Unfortunately neither of them is adapted to our present conditions. Except in the condensed sea water, we have no sources of the brine required as the starting point. Even the sea salt works, using solar evaporation, can-

not begin to furnish brine of proper concentration at anything like the cost of the brine produced from the salt beds of New York, Michigan and other states. To dissolve the salt from our desert deposits is far too expensive. Our gas works use oil for the production of illuminating gas and therefore cannot supply a prospective Solvay soda works with the necessary large supply of cheap ammonia. The cost of electricity from our hydro-electric installations is much too high for the use in the electrolytic process. Finally, we have no adequate market for the large quantity of calcium chloride of the Solvay process nor for the chlorine of the electrolytic process. This leaves us in the deplorable condition of having to develop some new and untried method, if we wish to start the very foundation of a general chemical industry. But fortunately, nature itself holds out the solution of the problem, characteristic only to our arid regions, in our desert alkalies. We have some deposits of very great magnitude which consist of sulphate of soda of as great or greater purity than the best salt-cake manufactured in the first phase of the Leblanc process. It is possible to mine and ship this sulphate to a convenient factory site at a cost considerably less than \$5 per ton. By using this natural salt-cake in the second phase of the Leblanc process, we do not only find a manufacturing method in the perfection of which, in all its details, hundreds of the best chemical engineers have worked for nearly a century, but we also omit all the unfavorable features, which resulted in its decline in competition with the Solvay process. The required capital for its installation is reduced to one-half or one-third by the omission of the costly apparatus for the manufacture of sulphuric acid and the conversion of salt into salt-cake in the first phase of the process. The great disadvantage of producing the enormous quantities of muriatic acid, for which we have no market, is entirely done away with. The only by-products are sulphur and carbonate of lime, of which the latter goes back to the black-ash furnace. Since nature has done, for our arid regions, the most costly part by offering the natural salt-cake as a raw product, it has given us an opportunity to revive the Leblanc process in a manner possible only and eminently characteristic in this part of the United States.

A careful calculation of the cost of production of soda-ash, using oil or producer gas as fuel, and taking \$5 per ton as the value of salt-cake delivered at the factory, results in a cost price of not to exceed \$10 per ton or 96 per cent soda-ash. It is hardly possible to over-estimate the immediate influence which the reduction of the cost of soda-ash to one-half of its present price will have in stimulating our already existing industries. Since it would at once put us on an even footing with the centers of the chemical industry in this country and abroad, it would enable us to manufacture our own cyanide for mines and orchards as well as permit the home production of a large line of fine chemicals. Last but not least, we could in time not only supply our home markets, but enter the export trade with a certainty of being able to hold our own against the keenest competition.

In close relation to the alkali industry stands the manufacture of potash salts. The prospects of its development on the Coast are certainly bright ones. The problems involved in the extraction of potash from kelp,

alunite and some favored desert deposits are at present under serious consideration. I have no doubt that they will be favorably solved in due time. The necessity, however, of utilizing all by-products, for a permanent commercial success, imperatively points to the establishment of a general chemical industry to take care of them. I am inclined to believe that both are so vitally dependent upon each other as to venture the assertion that together they are bound to succeed, while singly, the potash industry may fall far short of the sanguine expectations.

In considering the fuel situation, we are in the fortunate position of being able to meet all demands with a considerable margin in our favor. Our fuel oils furnish an excellent and economical fuel for all manufacturing purposes. It is only to be regretted that some of our best oilfields have passed into the control of other than American interests. The development of the refining industry is gaining larger proportions every year, which necessarily means increasing market for chemicals. One of the principal demands will be for cheaper soda products. In the refining of our crude oils, there are many phases of utilizing all possible by-products, which will have to await a general chemical industry for their ultimate commercial success.

#### LIGNITES AS A SOURCE OF GAS, TAR AND AMMONIA

In the lignites, of which a few large deposits exist in our state, another source of fuel is available. It is a matter of general knowledge that this coal cannot compete with the cheaper and more economical crude oil as a fuel for manufacturing purposes. The value of our lignites, however, are very large indeed, if we consider them in the light of a raw material for a chemical manufacturing industry. With the aid of producer furnaces and gas engines, our lignites are able to produce electric power even at a less cost than the average of our hydro-electric plants. In the by-product producer furnace, the lignites will give us an important source of ammonia and coal tar besides the electric power. The by-product coke oven adds to these a very serviceable coke for many purposes. The results obtained by me in an elaborate research on this subject are eminently satisfactory. I cannot forego the opportunity of stating a few of them.

Cost of electricity produced from lignite at the pit mouth with producer furnace and large unit gas engines.

#### ELECTRIC POWER PRODUCED FROM LIGNITE

|                                                                               |          |
|-------------------------------------------------------------------------------|----------|
| Cost of installation per kw. ....                                             | \$100 00 |
| Cost of production per kw.-hr., including 16% fixed charges on capital, ..... | 45       |

#### PRODUCTS FROM 1 TON LIGNITE IF USED IN BY-PRODUCT

| Coke Oven                                            |        |
|------------------------------------------------------|--------|
| 872 hp.-hr., valued at 1 cent. ....                  | \$4 36 |
| 60 gallons of tar valued at 3 cents .....            | 1 80   |
| 70 lb. ammonium sulphate valued at 3 1/2 cents ..... | 2 45   |
| 800 lb. of coke valued at \$2 30 per ton .....       | 1 00   |
| Total .....                                          | \$9 61 |

If you consider that the value of lignite at the pit mouth does not exceed \$1 per ton and that the total cost of operating such a plant is not more than \$2 per ton, these figures need no further explanation.

The coke obtained from our lignites certainly is not of a quality adapted to the operation of blast furnaces. But my as yet incomplete research work has resulted in showing a way, by which I feel positive first-class blast furnace coke can be manufactured from at least



some of our lignite deposits. This coke, however, is an ideal raw material for the manufacture of calcium carbide and calcium cyanimide. In the production of this coke not only sufficient by-products are obtained to pay most, if not all, of the costs of operating the plant, but a large source of electric power becomes available at a cost much lower than it could be bought from our hydroelectric installations. Calcium cyanamide as a fertilizer offers a practically unlimited market which cannot be overstocked for a good while to come. The ease with which it can be used in an endless number of reactions in the manufacture of organic chemicals is well known. Next to the all-important soda-industry, this utilization of our lignites appears to be the industrial development with the most brilliant future.

The tar from the producer furnace or coke oven has a well-established market value. It can, however, well be used in a tar-refinery, producing not only the more commonly known tar products such as phenols, pitch, etc., but also the cyclic hydro-carbons, viz., benzol, toluol, cresol, naphthaline, anthracene, etc., which opens the long vista of synthetic coal-tar products culminating in an aniline dye industry.

The last requirement for a successful industrial development, cheap iron for our apparatus and machinery we do not have, at least not now. We have large deposits of excellent iron ores, but we lack the all-important supply of cheap coke. All attempts to use liquid or gaseous fuel instead have not as yet proven successful, nor will they ever do so in my opinion. I have stated above that my researches make it seem probable that good coke will finally be obtained from some of our lignites, but this remains to be proven. All we can hope for at present is the successful development of the reduction of iron ores in the electric furnace, which we can very materially assist by a probable reduction of the cost of electric power by using our lignites as outlined above.

In my discussion, I have deliberately refrained from advocating any industrial development, for the success of which our raw-materials, available markets and local conditions do not only promise a highly remunerative investment at the present prices of like manufactured products, but also place us on an even footing with the industrial centers of the world, thereby enabling us to command our share of export trade. In addition, I have only advocated well-known and tried methods. No new and untried inventions or secret processes are required for our success. True, we must not expect success by using iron-clad method or recipes, which have been elaborated for other local conditions than our own. We must benefit by the experience of Europe and our own Eastern States and intelligently adapt their methods for our use.

I certainly am aware of the difficulties in the way of making California the home of a large and prosperous chemical industry. Our investors are generally not familiar with the nature and vast possibilities. There is a tremendous amount of educational work to be done before we can hope for a substantial success. On many occasions, I hear the candid opinion that for the purpose of chemical industrial pursuits, it is necessary to import a German, French, English, etc., chemist. This is by no means the case. Our American chemists are second to none. The only thing lacking is that our

investors are surely excellent judges of engineers, bookkeepers, skilled and unskilled workmen, but they fail to realize the fact that chemists are representative of just such an exact science as the civil engineer. We are too often considered to be no more or no less than a visionary drug clerk or an uncanny trance-medium. Many of our manufacturers would rather spend a fortune on a misty secret-process than pay an adequate remuneration to a competent chemist. We must combat most energetically this erroneous idea. Let us all stand together to emphasize and insist upon a realization of the fact that a chemist is not only an analyst but a very important factor in the general industrial development and the one paramount factor in the chemical industry.

If we succeed, if we create a soda industry utilizing our deposits of alkalies, if we start the use of our lignites as a raw product for the cyanamide and coal tar industry, if we assist in finding ways and means to reduce our iron ores, then we shall realize that our State is not only capable of producing its own chemical products, but is in some directions even more favored than other industrial centers. Instead of being the last outpost of civilization, California, through the shifting of the world's activities and the completion of the Panama canal, has become a center for the world trade highways. Nothing can do so much in making it a center in the industrial world as the development of a large and varied chemical industry. We have all the favorable conditions required and it rests primarily with us to realize them. In this effort, I ask for your hearty coöperation, as well as the coöperation of our colleges and manufacturers.

Los Angeles, Calif.

## The Future of Electrochemistry and Metallurgy on the Pacific Coast\*

By J. W. BECKMAN

I BELIEVE the Pacific Coast holds a better future for the manufacture of electrochemical and electro-metallurgical products than most parts of the world. This opinion is formulated after having traveled through Europe all the way from northern Sweden and Norway down to the southern part of Italy, visiting electrochemical centers.

These electrochemical centers are located where engineering skill finds that hydroelectric power can be developed at a reasonable price and where raw materials can be obtained readily. There are electrochemical plants in Norway north of the Arctic circle. The only access to those plants is by water route; the raw material is brought in from all parts of the world by boat and the finished products are shipped out from these plants by water. You could find conditions of a similar nature in most electrochemical centers of Europe. The primary factor is cheap power; availability of raw material is secondary, while the proximity to markets for their products as a rule is the third factor. We, on the Pacific Coast, are blessed by an abundance of water power, much of which can be developed at a very low figure provided sound and wholesome financing is done. We have on the Pacific Coast

\*Extracts from a paper read May 24, 1918, before the American Institute of Electrical Engineers. Author is president, Beckman & Linden Engineering Corporation, San Francisco.

large mineral resources, some of them practically untouched as yet, suitable for electrochemical or electrometallurgical manufacture. We have in Alaska situations identical with those on the coast of Norway, where power can be obtained at low figures on tidewater. We have stupendous opportunities on the Columbia River in Washington and we have the possibility of power developments all through the Southern Sierras.

In Europe, installations as small as a few hundred horsepower are used for electrochemical industries, and the day will come in California and the Pacific Coast, when we will find electrochemical industries located all through our mountains, where water powers even of small dimensions are available.

The quicker electrical engineers can realize that the big consumers of hydroelectric power are the electrochemical industries the better. The quicker the California hydroelectric development can realize that the day of the public service plant has passed for them the better. Future developments of the water powers of California and the Pacific Coast are not to be made for the lighting of dwellings and running of street cars, but for the industrial development of the state and to some extent for the operating of the railroads of the country.

#### ELECTROCHEMICAL INDUSTRY A GOOD POWER CONSUMER

Without any question the best consumer that any power producer can have is an electrochemical or electrometallurgical industry. They run on a power factor 90 per cent and better and as close as possible to a 100 per cent load factor. They run day and night the year around. The electric furnace load is a larger load than the electrolytic load. The largest electrolytic plant in the United States, I believe, takes about 10,000 kw., while the largest electric furnace plant in the United States absorbs 150,000 kw. The electric furnace load is built up by a few large units, while the electrolytic load is built up by a great number of small units.

We have as yet only a few electrochemical and electrometallurgical industries on the Pacific Coast. We have a few electric steel furnaces, but I think we have made a fair beginning and the opportunities are standing wide open. With the shortage of power in the East and with the increased demand for electrochemical products that not only exists today but will continue to exist, the future holds big opportunities in my estimation, along electrochemical and electrometallurgical lines for the coast states. We need badly a basic industry—such as iron production—but we hold in our hands all the essentials for a pig-iron industry similar to that of Sweden. Swedish iron is known all over the world with highest regard. California iron could be equally well known and equally well spoken of. We have enormous iron deposits—there is scarcely a county in this state that does not contain iron deposits and there are a number of them that have very large deposits of high-grade iron ore. For instance there is one deposit which is estimated to contain about 250,000,000 tons of 65 per cent ore.

Sweden reduces its ores by means of charcoal, made incidental to their lumber mill operations. It is produced either in by-product charcoal ovens or by heap charcoaling. The Pacific Coast holds more timber than Sweden and Norway combined, but charcoal is a scarce

commodity here. Therefore, to be able to develop an iron industry, it is essential that the timber and wood-working industries co-operate in producing charcoal.

#### ELECTRICITY REPLACING CHARCOAL IN SWEDEN

The electric shaft furnace is a complete success in Sweden. Every charcoal furnace that goes down for reconstruction is replaced by an electric shaft furnace; due primarily to the fact that one ton of charcoal will produce three tons of pig iron in an electric furnace, where before it produced only one ton in a charcoal furnace. The iron industry of Sweden is located in the very heart of Sweden, distant from the seaboard, and in a very limited area.

We have had unfortunate experiences in California in all attempts at making pig iron, but with the experience gained in Sweden we should be able to manufacture pig iron successfully for the needs of our present and future industries. The power necessary for this is available in large quantities in this state waiting to be developed. Blast furnaces are now being built in Sweden, taking up to 10,000 hp., and a few of these installed in this state would quickly show their influence in the metal markets.

The manufacture of electric steel is another industry which is needed here in conjunction with the pig-iron industry.

#### NITROGEN FIXATION A LARGE FIELD

Another big field for the development of electrochemistry and the power of this state is in the artificial fertilizer field. There are large stretches, as I understand it, of the valleys of California that contain excellent soil conditions and would be fertile fields, provided nitrogen in the shape of some fertilizer could be supplied them. Air is available everywhere, hydroelectric power can be developed at many points and at very low cost. We can either fix atmospheric nitrogen in the shape of nitrate or we can fix it in the shape of cyanamide, a large supply of lime rock is available and cyanamide answers many times as a fertilizer as well as nitrate.

In mentioning these developments I believe I have given the most important electrochemical industries suitable for large power developments. We have a large possible field for minor industries in the manufacture of alloys and chemicals. Many of these naturally are dependent on their possible market outlet, and I believe it is an important thing to remember on the Pacific Coast that our legitimate market, on which we should spend our efforts for the selling of our products, are not east of here, but west of here. The big industrial developments of the future are going to take place in China, Japan, Australia, and the countries south of us. We have golden opportunities there and the quicker we realize it the greater will our results be.

There is a tendency, and I want to warn you against it, for the Easterners and Eastern interests to say that it is impossible for us to accomplish such things in the West. It is a very natural, conservative tendency of people not acquainted with localities to make such judgments, but the important thing for us is to compare our resources with those of other localities on the globe where things have been accomplished in spite of handi-

caps. I am especially referring to the Scandinavian countries. Sweden and Norway are to-day factors—large factors—in the electrochemical field in spite of being handicapped by a lack of raw material and by distant markets. Another thing we have to bear in mind is that no industry was great before it was small. The only thing to do to build up the Pacific Coast's electrochemical industries is to copy what was done elsewhere; start them in a small way and gradually build them up to large ones. This, in turn, can only be accomplished by a close co-operation of electrical engineers and chemists of the Pacific Coast.

San Francisco, California.

## The Evaluation of Zinc Dust: A Proposed Method of Analysis\*

BY L. A. WILSON.

**Z**INC dust, or "blue powder," as it is commonly known, is being used in constantly increasing amounts for organic reductions, sherardizing, precipitation of gold and silver in cyanide practice, and in certain classes of paint.

Due to the demands of the trade for a material superior to the ordinary spelter furnace blue powder, the zinc dust sold to-day is largely a specially prepared product. The two particular qualities usually demanded by the consumers of zinc dust are fineness and high metallic zinc content.

The fineness is best determined by microscopical examination, but as usually carried out in practice, it is a simple matter of careful screening a sample through a nest of screens. On the other hand, the determination of the metallic zinc content, or reducing power as metallic zinc, is not so easily obtained and determinations by different methods or even by the same method with different analysts will show considerable variations. Since the manufacturer analyzes his product to maintain the grade, and the consumer is likely to analyze the zinc dust which he buys to preclude against accepting inferior material, there is need for a standard method that may be followed without great detail and which will obviate the misunderstanding originating from variant analyses. It is the purpose of this paper to cover only the determination of the metallic zinc contents of zinc dust, and not its physical properties.

### HYDROGEN EVOLUTION METHOD ADOPTED

After experimenting with the various proposed methods, the hydrogen evolution method was adopted because it was found to give the most consistently accurate results. The method and apparatus to be described later are the outcome of experimental work extending over several years, starting with the apparatus proposed by Franz Meyer and adding improvements and modifications as the work progressed. The method and apparatus have been used for hundreds of determinations for metallic zinc in zinc dust, and have given more accurate results than any method described in literature. For this reason they are proposed as a standard means for determining the metallic zinc contents of zinc dust.

The procedure and apparatus recommended for this method are fundamentally the same as in the Franz Meyer method.<sup>1</sup> By re-arrangement of apparatus and improvements in details of the procedure, the accuracy of determining the metallic zinc content of zinc dusts has been raised and the time required materially shortened. The average time required for high-grade zinc dust of which 90 to 95 per cent passes a 350-mesh sieve, and contains less than 0.3 per cent of metallic impurities, is about 1½ hours, against 2 to 4 hours with the Franz Meyer apparatus. With the latter apparatus there is no satisfactory way to speed up the determination, shaking being only mildly effective. In the proposed new method, the addition of strong acid accomplishes this purpose.

The method and apparatus may be best described with the aid of Fig. 1. A 1-g. sample of zinc dust is weighed and transferred as rapidly as possible to a small Erlenmeyer flask A, of 100 or 200-cc. capacity, in which is placed a piece of sheet platinum about 1.5 cm. square. About 5 g. of clean unoxidized ferrous sulphate crystals are added on top of the zinc dust and the flask nearly filled with distilled water saturated at room temperature with hydrogen gas. The object of adding the sheet platinum and ferrous sulfate is to increase the rate of hydrogen evolution by catalytic action.

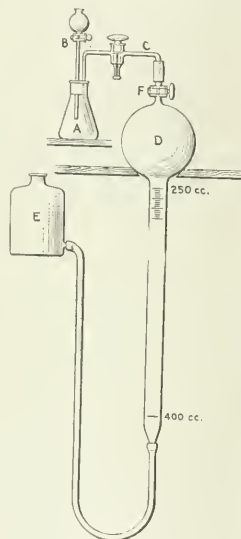


FIG. 1—APPARATUS FOR EVALUATION OF ZINC DUST

A further reason for adding the ferrous sulphate on top of the zinc dust sample is to coagulate the latter as much as possible when it becomes wetted, and thus prevent the floating of more than an unappreciable amount of the sample.

The rubber stopper containing separatory funnel B and connecting tube C is tightly inserted into the neck of the flask. A little distilled water is poured into B and the three-way stopcock in C turned to connect the flask with the downward outlet. Enough water is now run in from the separatory funnel to displace all the air in the flask and the connecting tube through the bore in its stopcock. The stopcock in C is now turned so that the downward outlet is in connection with the measuring tube D. By raising the leveling bottle E, containing 10 per cent sulphuric acid also saturated with hydrogen at room temperature, all the gas in D is displaced. The stopcock in C is now turned through 90 deg., so as to connect the decomposing flask A with the measuring tube D. The system is hence completely filled with liquid and ready for the generation of hydrogen. The measuring tube D has a total capacity of 400 cc. and is graduated from 250 to 400 cc. by 0.25 cc.

\*Excerpt of a paper, subject to correction and modification, presented at the Twenty-First Annual Meeting of the Amer. Soc. for Testing Materials, Atlantic City, N. J., June 25-28, 1918.

<sup>1</sup>Scott's "Standard Methods of Chemical Analysis"



Thirty cubic centimeters of 1:1 sulphuric acid are now poured into the separatory funnel. A small portion of this acid is allowed to run into the decomposing flask until a brisk but not too rapid evolution of hydrogen takes place. The acid, being much heavier than water, settles to the bottom of the flask and the action commences immediately. The gas evolved, together with some solution and a very small amount of zinc dust passes over into the measuring tube, displacing the acid there. When the action in the decomposing flask has slowed down, more strong acid is introduced until all has been added. During this time the acid in the measuring tube and flask is shaken so as to wash down the particles of zinc dust from the upper parts of the flask and tube now filled with gas. The particles in the measuring tube on coming in contact with the 10 per cent sulphuric acid are readily dissolved and generate their portion of hydrogen.

When all the zinc dust has been dissolved, water is run in from the separatory funnel to force the hydrogen over into the measuring tube and to fill the flask and connecting tube with water through to the stopcock *F*, which is then closed. After leveling with the leveling bottle the volume of hydrogen generated from the 1-g. sample at the prevailing atmospheric conditions is read from the measuring tube. The percentage of metallic zinc in the sample is then calculated from the following expression:

$$\text{Per cent of metallic zinc} = \frac{V \cdot (P - p) \times 0.29196}{(1 - 0.00367t) 760}$$

in which *V* = volume of gas in measuring tube at atmospheric conditions, *P* = barometric pressure, *p* = vapor tension of water above 10 per cent sulphuric acid at room temperature, and *t* = room temperature.

**Necessary Precautions.**—To obtain results of the highest accuracy, it is necessary when weighing out samples of zinc dust which are very finely divided, to keep the time of exposure as small as possible in order to minimize the oxidation that takes place with the oxygen of the air. It is also highly important when samples are to be held, that they be kept in ground glass stoppered bottles, completely filled, and sealed with paraffin or wax.

The two variables most likely to affect the results are temperature and barometric pressure. A change in the barometric pressure is practically always extended over a reasonable length of time. A careful reading of the barometer when the volume of gas in the measuring tube is read will eliminate any error from this source. A temperature change, on the other hand, affects not only the volume of gas, according to Boyle's law, but also affects the vapor tension of water and hence the actual pressure on the hydrogen when measured. Unlike barometric variations, changes in temperature can to a large extent be avoided by making the analyses in a room maintained at a nearly constant temperature, enclosing the apparatus in a cabinet, with door fronts that are opened only when measurements

are to be taken, and keeping all water and acid saturated with hydrogen in the same cabinet.

The rubber connection between the connecting and measuring tubes must be of heavy rubber and should be shellacked.

#### APPARATUS FOR CORRECTING TO STANDARD CONDITIONS DIRECTLY

Where a large number of metallic zinc determinations are carried out daily, the matter of calculating the results becomes laborious and is occasionally a point of error. This can be done away with in a simple manner.

A measuring tube, similar to the one used for measuring the gas, is sealed at the top below its stopcock filled with mercury and placed in a glass cylinder containing mercury.

Hydrogen, perfectly dry, is now introduced until it fills less than half the graduated stem of the tube. After leveling, this volume is read very accurately together with the room temperature and pressure. As a check, this volume may be read at another temperature. The volume is calculated to standard conditions. Enough pure water is now introduced into the measuring tube to entirely cover the mercury. After equilibrium has been attained, the volume temperature, and pressure are read and the dry volume of hydrogen calculated will check with the original volume introduced. Fig. 2 shows this apparatus in readiness for use.

The volume of gas in this tube will vary according to atmospheric conditions, but since the volume of dry gas at standard conditions is known, the factor to correct the volume of hydrogen gas evolved in a determination to standard conditions is a simple matter of calculation, as given by the following expression:

$$\text{Per cent of metallic zinc} = \frac{V_D \cdot v_s \cdot 0.29196}{v_d}$$

in which *V<sub>D</sub>* = volume of gas evolved in determination, *v<sub>s</sub>* = volume of dry hydrogen in correction tube reduced to standard conditions, and *v<sub>d</sub>* = volume of hydrogen in the correction tube read at the same time as *V<sub>D</sub>*.

Where the amount of work carried out would warrant it, a table may be made up giving the factor for each graduation on the tube. The factor is the calculated result of  $\frac{v_s}{v_d} \times 0.29196$ , where *v<sub>d</sub>* is the volume for

each graduation. We can now directly convert the gas volume in the measuring tube after each determination directly over into percentage of metallic zinc.

The vapor tension of water is slightly lower above 10 per cent sulphuric acid than above pure water, and the error that would be introduced by taking the volumes in the correction tube directly would give results ordinarily about 0.3 per cent low.

The table of factors calculated is corrected to take this into account. This difference is indicated in Fig. 3, which shows the curves of vapor tension of water above pure water and dilute sulphuric acid plotted against temperature. The curves are for the following:

*A* = Vapor tension above pure water;

*B* = Vapor tension above sulphuric acid containing 10.89 g. H<sub>2</sub>SO<sub>4</sub> and 100 cc. water;

*C* = Vapor tension above sulphuric acid containing 18.4 g. H<sub>2</sub>SO<sub>4</sub> and 100 cc. water. This solution is 10 per cent H<sub>2</sub>SO<sub>4</sub> by volume and the curve was obtained by interpolation, using curves *B* and *D*;

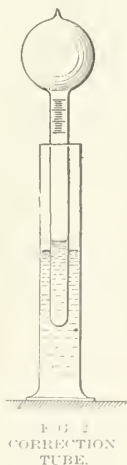


FIG. 2  
CORRECTION  
TUBE.

$D$  = Vapor tension above sulphuric acid containing 32.02 g.  $H_2SO_4$  and 100 cc. water.

It will be seen from curves  $A$  and  $C$  that where the temperature changes over a large range the use of a correction tube will give slightly erroneous results, due to the increasing difference in vapor tension above water and 10 per cent sulphuric acid with increasing temperature. In this case, results should be calculated, using

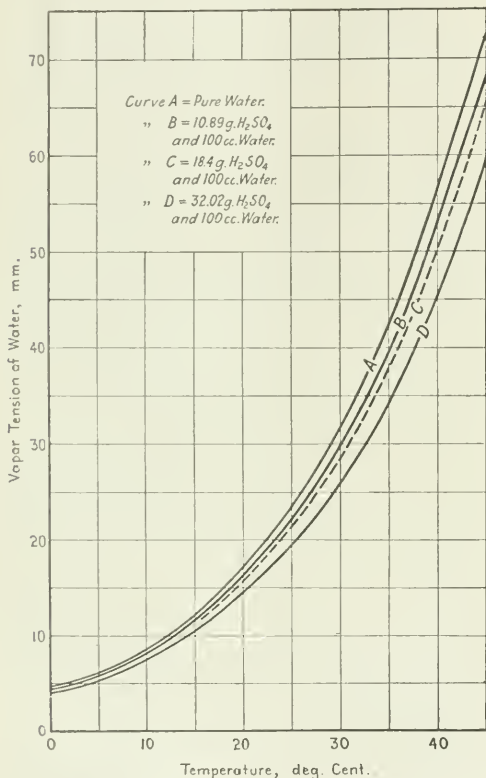


FIG. 3. Vapor Tension of Water above Pure and Dilute Sulphuric Acid. Data for curves A, B and D from Landolt-Bernstein, page 167. Curve C interpolated.

the elementary formula. Where the laboratory temperature is controlled, the correction tube gives satisfactory results and is a valuable additional piece of apparatus.

In this proposed method all known possibilities of error have been taken into account and accurate reproducible results are obtained. The results of many analyses extending over a long period of time, and the running of many check samples as unknowns, have confirmed this and prompt the putting forward of this method and apparatus as a standard means for determining the metallic zinc content of zinc dust.

Gold exports from the United States during eleven months of the fiscal year ending June 30 have exceeded imports by \$95,000,000. This, as it happens, is the largest net export in the country's history and compares with \$661,000,000 excess of gold imports in the same period a year ago.

## Government Badly Needs Trained Men

With a perfect organization at home for producing the material of war, victory will be easier. The actual fighting forces must have the constant support of a host of highly trained experts if the nation's greatest undertaking is soon to be successful. The United States Civil Service Commission, whose duty it is to recruit the civilian army, announces that right now the civilian branches of the Army and Navy are in urgent need of thousands of technical men to work in direct connection with the prosecution of the war.

Among the positions now open are the following:

|                                                               | Usual entrance salary     |
|---------------------------------------------------------------|---------------------------|
| Metallurgist .....                                            | \$3,000 a year            |
| Assistant chemist and metallurgist .....                      | \$2,000 a year            |
| Metallurgical chemist .....                                   | \$1,600 to \$2,400 a year |
| Assistant metallurgical chemist .....                         | \$1,000 to \$1,600 a year |
| Metallographist .....                                         | \$1,500 to \$2,000 a year |
| Assistant chemist .....                                       | \$1,800 to \$2,000 a year |
| Junior chemist .....                                          | \$1,200 to \$1,440 a year |
| Powder and explosives chemist .....                           | \$1,600 to \$2,400 a year |
| Assistant powder and explosives chemist .....                 | \$1,000 to \$1,600 a year |
| Chemical engineer .....                                       | \$1,600 to \$6,000 a year |
| Assistant chemical engineer .....                             | \$1,200 to \$1,600 a year |
| Superintendent of high explosive and acid plant .....         | \$1,500 to \$1,800 a year |
| Laboratory aid .....                                          | \$4.00 a day              |
| Tolul expert .....                                            | \$1,800 to \$3,000 a year |
| Operative in gas manufacture .....                            | \$1,600 to \$2,400 a year |
| Assistant operative in gas manufacture .....                  | \$3.00 to \$5.00 a day    |
| Superintendent of nitrate and chemical plants .....           | \$2,400 to \$6,000 a year |
| Assistant superintendent of nitrate and chemical plants ..... | \$1,600 to \$2,400 a year |
| Engineering draftsman .....                                   | \$3.04 to \$7.04 a day    |
| Mechanical draftsman .....                                    | \$4.00 to \$8.00 a day    |
| Apprentice draftsman .....                                    | \$4.80 a year             |
| Metal furniture draftsman .....                               | \$4.00 to \$6.00 a day    |

A further long list of technical positions in the War, Navy, and other departments are to be filled. For the positions named applicants are not required to report at any place for examination, but are rated upon their education, training, and experience, and in some cases on work submitted with the application. Physical ability is also considered in some instances. Ratings are arrived at from information set out in the application blank and from corroborative evidence.

The Civil Service Commission calls particular attention to the fact that all necessary information concerning civil service positions, and application blanks therefor, may be obtained free of any cost by applying to the Commission's representative at the post office in any important city, or by addressing "The United States Civil Service Commission, Washington, D. C." Positions of junior chemist and many of the drafting positions are open to women.

## Chicago Men Unite for War Work

A score of the leading Chicago Engineering and Technical Societies have organized a Joint War Committee: Chairman, F. K. COPELAND; Vice-Chairman, W. L. ABBOTT; Treasurer, W. A. FOX; Secretary, E. S. NETHERALT, 1735 Monadnock Block, Chicago, Ill.

Board—WM. HOSKINS, C. A. KELLER, C. E. LORD, C. F. LOWETH, I. RANDOLPH and R. S. SCHMIDT.

The purpose of this organization is to get the various technical men together and combine their individual efforts in rendering any aid of value in scientific work, pertaining to the war.

# The Possibilities of Powdered Coal as Shown by Its Combustion Characteristics\*

An Exposition of the Merits of Powered Coal Based on Its Efficiency and Flexibility to Meet Varying Demands—Advantages of One-Stage Combustion—Importance of Thorough Mixing

BY W. G. WILCOX

INDUSTRIAL efficiency and the smooth operation of the machinery of industry require continuous supplies of power, materials and labor. These are of equal importance in that the lack of any one of these is equally disastrous.

The wonderful work being done by women in Great Britain and France shows us that we also have great reserves of labor hitherto unsuspected and as yet practically undeveloped. When we regard the percentage of available men put in the field by both France and Great Britain—when we know that their industrial production is nevertheless carried on today at a high peak due to the utilization of women in industry, we can rest assured that the solution of our own labor shortage will follow along identical lines. The problem is by no means insurmountable.

## PRESENT FUEL SITUATION

Power and materials, the other two factors that make up the balanced ration of industry, are bound up in each other. No matter how great the resources in raw material, these will be of no value unless the power necessary for transportation, manufacturing and fabrication is available. The greatest source of power is through the combustion of fuels. The situation in regard to fuel is so alarming as to call for the most careful consideration. Production of fuel scarcely meets consumption. Regional Director for the U. S. Railway Administration, R. H. Aishton, formerly president of Chicago and Northwestern Railway, states that "There were times last winter when there was not four hours' fuel in the city of Chicago between freezing people to death and keeping them warm." This is not the statement of an alarmist but of a man, who as director of all the great coal-shipping railroads of the Middle West, knows the facts. Concomitant with the greatest demand for coal we have ever experienced we find the greatest natural-gas field of West Virginia failing alarmingly. This brings into the list of coal consumers new users who have formerly depended on natural gas. At the same time fuel oil is steadily becoming harder to obtain and almost prohibitive in cost. The oil-fired forge furnaces of the East and the copper reverberatories and cement kilns of western Texas, Arizona and Utah, the potash producers of Nebraska and the apartment houses of Seattle, alarmed at the fuel-oil situation must and are seeking coal as their salvation. This means another new demand for coal, a further burden on railroad transportation. As the railroad must have more coal to haul more coal the seriousness of the situation increases geometrically.

\*Paper delivered before the Western New York Section of the American Chemical Society, May 31st, 1915

For this situation with all the elements of danger it presents there are three possible solutions:

1. Stimulation of the production and transportation of fuel,
2. Developing efficient methods for utilizing low-grade fuels hitherto practically unused, and
3. Burning fuel so much more efficiently than we now do that the amount available will be adequate for all needs.

An estimate of the possibility of speeding up coal production and coal transportation can be left to those who are at present arguing the pros and cons of whether it is the railroad or the mine which limits production. At best there does not seem to be much reason to expect any great increase in production.

Our greatest opportunity for success in meeting the fuel situation lies in the efficient combustion of both low-grade and high-grade fuels. It is far wiser to save avoidable losses than to increase supply and thus compensate for losses. It is preëminently the patriotic and professional duty of the chemist and engineer to work for the more efficient utilization of fuel. We should therefore study critically the lines along which we should work. Among the more efficient types of combustion is the use of powdered fuel. By considering the nature of powdered coal as a fuel and its combustion characteristics we can learn its possibilities in the present fuel situation. The requirements necessary in perfect combustion show the weaknesses of present methods and the possibilities of powdered coal combustion.

What are the known avoidable losses in combustion? What are the essentials necessary for combustion efficiency?

## ESSENTIALS OF GOOD COMBUSTION

Assuming correct furnace and flue design, and proper and controlled draft, the essentials of good combustion are:

1. *Complete oxidation of all the combustible in the coal to avoid loss of combustible in ash and up the stack.* The loss of unburned carbon in the ash will vary with different types of fuel, different types of ash and the percentage of ash in the coal. It will also vary with the type of stoker used and boiler load carried. In hand-fired practice it will vary with the skill of the fireman; and in producer operation it will vary according to the quality of the coal, type of producer and operating conditions.

Using an Illinois coal of the following analysis:

|                       | Per cent |
|-----------------------|----------|
| Sulphur .....         | 5.5      |
| Volatile matter ..... | 34.0     |
| Fixed carbon .....    | 42.0     |
| Ash .....             | 18.5     |



the results of one of the large users in the Middle West show the following losses in the ash:

| Actual per cent of coal lost                               |                |
|------------------------------------------------------------|----------------|
| Over-feed stokers—25 per cent unburned carbon in the ash   | 4.6            |
| Chain grate stokers—35 per cent unburned carbon in the ash | 6.5            |
| Hand fired—35 per cent upwards unburned carbon in the ash  | 6.5 and upward |

This particular consumer has two different types of stokers and also does a large amount of hand-firing. His consumption is over 100 carloads of coal per day; operation is under the direction of skilled technical men who have actual data as to losses.

In producer operation using a good-grade coal, 20 per cent of unburned carbon in the ash is the minimum figure. Under bad conditions when poor, fine, wet coal was used and with variable steam pressure, as high as 55 per cent unburned carbon will be found in the ash even with a first-class modern producer.

With any type of stoker or producer the loss due to unburned carbon in the ash increases with the increasing ash content. This is not a straight-line function, partly due to the human element, while the increase in unburned carbon with increasing ash is affected considerably by the nature of the ash, its fusibility, etc. Certain coals, although of high heating value, offer enormous difficulties to efficient operation when put through a producer, burned on grates or on stokers. A case in point is a coal obtained in southwestern Virginia not far from Bristol, Tenn. This coal runs over 14,000 B.t.u. and contains under 8 per cent ash. Occurring in this coal are fine laminations of pure crystalline transparent calcite which is present in just sufficient amount to flux the other ash materials and given continuous trouble from clinkering. Even in a modern mechanical producer this coal is a source of continuous trouble and interruption of operation. Due to the mechanical occurrence of the ash washing does no good.

Another case is a Colorado coal of the following analysis:

|                 | Per cent |
|-----------------|----------|
| Ash             | 6.66     |
| Volatile matter | 43.76    |
| Fixed carbon    | 49.58    |
| Sulphur         | 0.93     |
| B.t.u.          | 12886    |

The ash of the coal melts, runs down on the grates and freezes there while the coal itself disintegrates and chokes up the fire.

There is, of course, also the loss of unburned carbon up the stack which although as much as one or two per cent under some conditions should be small with good operation.

2. *Control of combustible and air.* This is absolutely essential, if we are to secure maximum flame temperature with a corresponding increased rapidity of heat transfer. The more rapid the heat transfer in the furnace or boiler the higher the capacity of the furnace and, in general, the greater the efficiency. This may well be shown by the following example: The theoretical flame temperature for hydrogen is 2010 deg. C.; while with 25 per cent excess air, this figure drops to 1764 deg. C. This fact has long been realized in boiler practice and considerable emphasis has been placed on high content of CO<sub>2</sub> in the flue gases and a minimum amount of excess air.

3. *Control of flame length.* In order to maintain in a furnace the conditions which the design of the fur-

nace, the operation, or the metallurgical process occurring therein, requires, it is essential that the length of the flame be under control. An example is found in a recent development in firing copper reverberatory furnaces. For a long time it has been a practice to fire copper reverberatories with an insufficient amount of air, admitting the amount of air required to complete combustion at ports along the side of the reverberatory. It has recently been found with oil-fired reverberatories that if the number of oil burners firing into the furnace is increased and the mixture of oil and air so adjusted as to give complete combustion with a short, hot flame, the capacity of the furnace is increased in some cases as much as 50 per cent, while the fuel ratio is better than anything yet obtained with oil in reverberatory practice. This is also true of powdered-coal-fired reverberatories. In this particular operation it has been found that a short, hot flame leads to most efficient operation and highest furnace capacity; but there are other processes in which the reverse is true.

#### ECONOMIES EFFECTED BY POWDERED COAL THROUGH FURNACE EFFICIENCY

In changing types of fuel, for example in changing from the hand-firing of coal to powdered-coal combustion, the economies met with are usually far greater than those which can be figured from the known losses. The increase in capacity is usually so great that it can only be attributed to increased furnace efficiency. This increased furnace efficiency in all probability follows from the fact that the operator is now able to maintain the flame length and type of combustion for which that particular furnace design is best suited. When, in changing from hand-fired practice to powdered-coal combustion, it is found that only from 30 to 40 per cent as much coal is used as formerly, the greater proportion of the saving is very evidently due to change in the efficiency of the furnace.

4. *That type of combustion which is to be most efficient must possess flexibility in capacity.* Flexibility in combustion means rapid response. Only in this way can a cold furnace be brought to heat very quickly or a standby boiler come up to peak load rapidly. This makes for efficiency because it reduces the fuel consumption during the standby period. Many operations also require considerable variation in heat input at different stages of the operation; in order to secure highest efficiency under these conditions, extreme flexibility as to "combustion load" is demanded.

5. *Control of the nature of the combustion.* In many operations it is not only necessary to heat uniformly, quickly and efficiently, but it is equally important to maintain a certain chemical condition in the furnace. This condition may be oxidizing, reducing or neutral. In any case the control of combustion should be such that the desired condition may be maintained within very close limits; failure to do so means a waste of fuel. Maintaining an oxidizing condition without ability to control it within close limits, will result in having present too much of an excess of air, which will lower flame temperature, lessen output, lower furnace efficiency and reduce fuel efficiency. Likewise a reducing condition, unless maintained within close limits, means that fuel is needlessly wasted. If the operation demands a neutral condition, there may be some loss

due to spoiling of product, unless there is the ability to maintain the neutral condition quite exactly.

#### ONE-STAGE VERSUS TWO-STAGE COMBUSTION

6. *One-stage combustion.* The best example of two-stage combustion is the producer. The producer affords, in many of its applications, an overall efficiency which is considerably higher than that obtained by other methods. Nevertheless we should clearly realize that in the process for making producer gas there is an inherent loss of at least 20 per cent because of the inability to gassify without forming a certain percentage of  $\text{CO}_2$ , due to heat losses at the producer and losses in sensible heat from the gas between the producer and the point at which it is used.

There is another serious objection to two-stage combustion. When combustion is completed, the final flame temperature is lower than in a one-stage process. Unless we resort to such devices as the recuperator or regenerator, high temperatures cannot be reached. Furthermore a two-stage combustion results in "cracking" some of the most valuable constituents of the coal with the formation of smoke in the furnace and soot in the producer. This has been shown very well by Kreisinger, Augustine and Ovitz in *Bulletin* 135 of the Bureau of Mines, in their study of the combustion of coal and furnace design.

Having considered the essentials for efficient combustion, we can correctly estimate the value of powdered coal as an efficient fuel, by studying its characteristics, and seeing to what extent these make it possible to maintain the essentials of good combustion. In the same way we can also ascertain the conditions demanded for success in the combustion of pulverized fuel.

#### FUEL CHARACTERISTICS OF POWDERED COAL

The simplest way to regard the combustion of coal is that it is a reaction between solid fuel and oxygen. It is therefore a heterogeneous system; consequently the velocity of the reaction and its completeness will depend upon the surface exposed by the solid, the pressure of the reacting gas and the intimacy of the mixture. By grinding an inch cube of coal so fine that 85 per cent will pass a 200-mesh screen, we have increased the surface exposure from 6 square inches to approximately 1800 square inches. We have therefore increased the velocity of combustion approximately 300-fold. By doing so, we have immediately changed the characteristics of the fuel. We now have a fuel relatively 300 times more active than the inch cube of coal, a new type of fuel which has in it inherent possibilities not met in lump or slack fuel. By increasing the surface exposure 300-fold, we have speeded up combustion proportionately. This carries with it a further effect. The increase in combustion velocity also increases the rapidity of heat evolution, and consequently quickly raises the temperature of the rest of the material. This temperature rise, which is much more rapid than in the normal combustion of coal, will double the velocity of combustion each rise of 10 deg. C. The increased velocity due to greater surface exposure and that due to temperature rise are superimposed on each other so that we have with pulverized fuel a combustion which is hundreds of times faster than when burning lump coal.

Having a finely divided fuel it is possible to form a mixture of fuel and air so intimate that each small particle of coal is surrounded by the proper amount of air. In this condition, by maintaining the proper velocity of the air current, the fuel can be carried into the furnace in suspension and there burned completely, efficiently and rapidly.

#### ESSENTIALS FOR COMBUSTION EFFICIENCY

It is of course a simple matter to mechanically control the amount of powdered coal delivered to the furnace in a given time. It is also quite possible to control the amount of air delivered with the coal. If, then, we deliver to the furnace an intimate mixture of air and powdered coal and have control of the amount of coal dust and air delivered, we have the prime essentials for highest combustion efficiency. These are the possibilities in utilizing coal in powdered form. The degree to which they are attained depends entirely upon how carefully we study the characteristics of the fuel before and during combustion.

The amount of coal dust delivered to the furnace can be controlled simply and positively by using as a feeder a properly designed screw, operated at variable speeds. It is also a simple matter to control the volume of air admitted with the fuel. But the highest efficiency possible with this type of fuel will not be obtained unless we work out a correct way in which to mix a finely divided solid with air.

A study of the methods for making such a mixture, immediately shows that the methods commonly used in making uniform mixture of two miscible liquids or a uniform solution of a solid in a liquid, or the methods used in mixing finely ground solids are not only useless in this case, but will actually separate the coal dust from the air. Ordinary mixing is done by agitation; this agitation is usually accomplished by baffling, stirring, shaking or similar devices. When, however, such methods are applied to a mixture of gas and finely divided solid, the solid tends to separate out due to its much higher specific gravity. This, in fact, is the principle of the well-known Cyclone dust collector. Any mixing device which results in such agitation of the dust and air as to give a centrifugal effect, will tend to separate out instead of mixing the air and the dust. Any mixing device along these lines must necessarily fail to give an intimate, perfect mixture.

The importance of intimately mixing the coal dust and air cannot be exaggerated. The rapidity of combustion is a direct measure of the intimacy of mixture. This is well illustrated by comparing the ordinary gas flame with the flame obtained in the Bone combustion system. The Bone system consists in forcing the proper proportions of air and gas through a diaphragm having numerous small interstices which results in a mixture that is nearly perfect. When this mixture is ignited on the other side of the diaphragm, we have only a film of flame.

#### IMPORTANCE OF THOROUGH MIXING

The poorer the mixing the longer the flame. The flame simply outlines the area in which combustion is taking place and the length of the flame is a measure of the time element necessary to accomplish combustion. This time element—other conditions being equal—is

absolutely a function of the intimacy of mixture. This has already been noted by Breckenridge some ten years ago, when in *Bulletin* No. 325 of the United States Geological Survey, page 171, he stated:

"The conclusion is reached that the velocity of combustion decreases enormously from the surface of the fire to the rear of the combustion chamber, where it is relatively very small, the practical application is that little is to be gained by adding further length of smooth combustion chamber, which would be commercially as poor an investment of capital as to add to the length of a Corliss engine cylinder and stroke; we must resort to thorough mixing."

On page 178 of the same bulletin, Breckenridge further stated:

"Mere length of combustion chamber counts for little—that mixing is what counts."

These two excerpts from Breckenridge's study of four hundred steaming tests have since been amply confirmed by the work of Kreisinger, Augustine and Ovitz, in *Bulletin* No. 135 of the Bureau of Mines. The work of these investigators confirmed and emphasized the previous observations of Breckenridge and they quote him as I have. They also state on page 130:

"Evidently, the length of the flame depends not only on the nature of the combustible, the excess of air, and the rate of firing but also to a large degree on the rate of mixing of the combustible gases with the oxygen of the air. It has been shown that the tendency of the gases is to flow in parallel streams even when the air was introduced into the furnace in many small streams through the tuyeres of the furnace."

So far we have considered this type of fuel from the point of view of the possibilities which it affords. We have also studied the characteristics of the mixture of coal dust and air in order to ascertain what methods should be employed to insure delivery to the furnace of an intimate, controlled mixture of fuel with the requisite amount of air. A fuel having the great possibilities offered by a finely divided combustible, is of extreme importance especially under present conditions. Because of these possibilities, all of which are capable of being realized and which are satisfied by commercial equipment now on the market, there is less excuse for permitting inefficient operation with this fuel than with stoker or hand-fired practice. Apparatus, properly designed and fundamentally correct in principle, will give proper efficiency. Such apparatus by giving an intimate and controlled mixture of fuel and air to the furnace will permit the highest furnace efficiency.

#### CHARACTERISTICS OF POWDERED COAL AND FUEL OIL

Just as in the past there has been a remarkable failure to realize the necessity for intimately mixing air and coal dust, neither has there been sufficient consideration of the characteristics of this fuel when burning. Powdered coal has the characteristics of a rich fuel of somewhat higher kindling temperature than producer gas, natural gas or fuel oil. To illustrate the fact that it is a rich fuel, we can compare the available B.t.u. in a cubic foot of a correctly proportioned mixture of powdered coal and air and the available B.t.u. in a cubic foot of a correctly proportioned mixture of pure methane and air. Taking a Pittsburgh vein coal (heating value 14,157 B.t.u.) of the following analysis:

|                    | Per cent |
|--------------------|----------|
| Volatile .....     | 35.4     |
| Fixed Carbon ..... | 58.5     |
| Ash .....          | 6.1      |

we find that a cubic foot of a correctly proportioned mixture of coal dust and air has available 107 B.t.u., while a mixture of pure methane and the proper amount of air has available per cubic foot, 62.3 B.t.u.

A further illustration is shown by the theoretical maximum flame temperatures of several fuels.

#### THEORETICAL MAXIMUM FLAME TEMPERATURE USING COLD AIR

|                                              | Deg. C. |
|----------------------------------------------|---------|
| Hydrogen .....                               | 2010    |
| Carbon Monoxide .....                        | 2050    |
| Natural Gas .....                            | 1906    |
| Pure Methane .....                           | 1958    |
| Pittsburgh Coal (Analysis given above) ..... | 3470    |

#### FACTORS CONTROLLING RAPIDITY AND COMPLETENESS OF COMBUSTION

The rapidity of combustion and the completeness of combustion of a mixture of coal dust and air depends upon a number of factors:

1. *The velocity and pressure at which it is passed into the combustion chamber.* If the velocity of the incoming stream of powdered coal and air is above the velocity of flame propagation, combustion will not take place until the mixture has slowed down to a point where it does not exceed the velocity of flame propagation. When powdered coal is fired at high pressure and high velocity, combustion frequently does not begin until a point four to six feet from the mouth of the burner. A similar example is found in the plumber's blow-torch when too much air is used, or in the Bunsen burner when the gas pressure is too high. High-pressure, high-velocity firing not only slows down combustion thus increasing the size of combustion chamber necessary, but has a destructive action on the furnace. It has been well established that high velocities in the combustion chamber or a blow-torch effect due to firing at high pressure (whether oil or gas be used as a fuel) are always very destructive to the brick work. This action is increased in high-pressure firing of powdered coal since in addition to the erosional effect of gases at high temperature traveling at high velocity, there is a fluxing action by the melted ash. Furthermore, with such high-velocity combustion, the slagged ash will be carried along mechanically, leading to further furnace troubles. In one case this resulted in a serious deposit of slag on the mud drum of a vertical waste-heat boiler at the end of a long reverberatory furnace. Slowing down the velocity not only hastens combustion, but makes it possible to eliminate much of the slag. When the velocity is low the coalesced particles of slagged ash are either larger than will be carried by the velocity of the gas or this condition is so nearly approached that a slight change in direction of the flame will result in dropping out the slag. Thus, in addition to being correct combustion and necessary in order to avoid excessive furnace maintenance costs, low-pressure, low-velocity combustion permits by slight change in flame direction dropping out a very large percentage of the slagged ash in the early part of combustion, where it can be removed and will not interfere seriously with efficient metallurgical operations.

The velocity of combustion is not only dependent upon the fineness of the particles of coal, intimacy of mixture and the velocity of the stream of combustible and air, but is affected by the temperature of the combustion chamber. The kindling temperature of a mixture of powdered coal and air is



higher than either that of oil or gas; consequently for successful and complete combustion, it is necessary that the combustion chamber be maintained above a certain minimum temperature and that combustion is practically complete before the products of combustion pass over the heat absorbing surfaces. Just as you can extinguish a gas flame by passing over it a piece of wire gauze, so the effect of a chilling surface will be even more marked with this combustible material than burning gas, since the particle of coal is infinitely larger than a molecule of gas and the kindling temperature is also higher. This has a direct application in the successful firing of locomotive-type boilers, water-tube boilers and return-tubular boilers. If the combustion of powdered coal is not sufficiently developed before the flame enters the tubes of the locomotive-type boiler, combustion will be checked and coked coal settle out in the tubes. If on the other hand combustion is sufficiently developed before the flame is brought in contact with the heat-absorbing surface, a complete combustion and high efficiency are obtained. In any furnace operation and in furnace design, this must be borne in mind if success is to be expected.

#### RAPIDITY OF COMBUSTION OF LOW-PRESSURE MIXTURE

A study of the flame developed by a low-pressure, intimate mixture of coal dust and air shows that combustion is extremely rapid. In a copper reverberatory furnace in Florence, Colorado, where this type of combustion is used, coal burned at the rate of approximately one ton per hour develops a flame which vanishes within six feet of the burner, combustion being complete at that point. In order to bring out exactly what this means, let us translate it into terms of natural gas, in which case the fuel consumption would be approximately 26,000 cubic feet per hour or 433 cubic feet per minute. Picture to yourself this quantity of gas being burned at low pressure and developing a flame only six feet long. Gas samples taken in the flame, show a content of CO<sub>2</sub> as high as 16 per cent only five feet from the mouth of the burner. This will give an example of the rapidity with which combustion can be obtained and the extremes which are possible in shortening the flame. It is equally possible with proper equipment to lengthen the flame until it will spindle out a distance as great as 100 or 120 feet. However, with an intimate controlled mixture, this must be done by supplying insufficient air. Under such conditions combustion is incomplete and the flame spindles out because combustion continues to develop throughout the length of the furnace as air leakage supplies additional oxygen. This is an additional proof of the statement previously made that the length of flame is an actual measure of efficiency of mixing and the adjustment of the fuel-air ratio.

Thus it is seen that we have changed entirely the characteristics of coal as commonly known. Powdered coal is a fuel of extreme flexibility in that the amount burned can be varied within wide limits. It is a fuel which develops a flame the length of which can be adjusted. The character of the flame can be altered to suit the metallurgical operation. In short the basic fuel, coal, has acquired the characteristics of oil or gas, but with better and closer control than in the case of oil or gas. Furthermore, the possibilities of this

fuel are not only capable of realization, but are actually being utilized in commercial practice today. To the flame characteristics of a rich fuel, developing a flame like oil or gas, is added a degree of control not yet obtainable in burning either oil or gas. This statement is made advisedly. The possibilities of such combustion for the improvement of processes, for fuel economy, for increasing output, through its ease of control and elimination of heavy labor, are today realized by few. Due to the psychological attitude of labor and the scarcity of skilled operatives, it is far more difficult than ever before to secure high efficiency and good operation in hand-firing, stoker-firing or in producers—in short wherever such efficiency depends upon constant watchfulness and hot, heavy, disagreeable work. For these conditions powdered coal substitutes an ease of control such that the equipment can be handled by an old man or a boy, while it is so simple that a man of ordinary intelligence can soon be taught all that is necessary for good efficiency in operation. The possibilities of such control in the place of present day combustion methods, which permit high efficiency only by the most strenuous effort, through substituting for these a type of combustion whereby high efficiency is easily obtained, is certainly of great importance to us at the present time.

#### CONTROL OF HEATING CONDITIONS IN CHEMICAL PROCESSES

To those who are in touch with many diversified chemical industries, the possibility of maintaining within close limits, heating conditions which are oxidizing, reducing or neutral at will, conditions which once adjusted will remain constant—barring mechanical or electrical interruptions—will undoubtedly suggest many cases where such combustion will offer new economies and betterments in their processes. A good example of this is shown in a powdered-coal installation in a malleable iron foundry in Buffalo. The positive and simple control offered by their equipment has not only resulted in the highest fuel ratio yet reached in malleable-iron practice, namely between 5 and 6 lb. of castings per pound of coal, but also through maintaining a slightly reducing condition in the annealing oven the oxidation of the cast-iron pots has been so reduced that the cost of pots per ton of castings has been cut from \$2.25 to 83 cents. These two results are concrete proof of the possibilities of this type of combustion. The high fuel-ratio shows efficient combustion; the decrease in pot cost shows control of combustion; and the high fuel-ratio in conjunction with the maintenance of a reducing condition shows exactness of control.

A still more striking example of the possibilities of controlled combustion may be cited of a powdered-coal installation now being made. In this particular process a cast-iron container is maintained continuously at a temperature of 1000 deg. C. This is not only close to the melting point of the material but is a temperature so high that the oxidation caused by the unavoidable excess of air met in ordinary methods of combustion results in enormous maintenance costs due to quick failure of the container. In this installation it is confidently believed that the combustion can be so controlled as to cut oxidation to a minimum so that the life of the container will be greatly increased.

#### EFFECTS OF ADMINISTRATION EFFORTS AT FUEL DISTRIBUTION

The Fuel Administration has wisely districted the coal fields of this country. In doing so they have upset in many cases what has been standard practice for years in some of the industries. The cities of Iowa have for years used anthracite for house heating; today they must use Iowa and Illinois coal. The malleable-iron foundries of Chicago have in the past bought Elkhorn coal from Kentucky with which to melt iron in the air furnace; today they are confronted with the problem of using high-sulphur, low-grade, Middle Western fuel. While temporary relief will undoubtedly be granted through permits to use high-grade coal for melting, it is probably only a question of time before they will be compelled to work out successful methods for burning the lower-grade coals of their immediate vicinity, from which they should naturally draw their supply of fuel. Nebraska must learn to use her lignites, as must the Dakotas. Western Texas must do the same. Seattle, which has in the past heated apartment houses with fuel oil, must learn to do so with the lignitic coals of Washington.

While these communities are facing the problem involved by the use of these low-grade fuels, every user is experiencing a marked decrease in the quality of his coal, regardless of the source. In the J. E. Aldred lecture delivered at Johns Hopkins University this year by Mr. E. G. Bailey, he shows that due to the enormous demand for fuel, shortage of labor and other conditions, the ash content in coal has increased during the year of 1917 at least 5 per cent, resulting in an increase in coal consumption, due to the decreased heating value and lower efficiency, which reaches as high as 10 per cent. Figuring on a basis of six hundred million tons of coal produced and marketed last year, thirty million tons of dirt, slate and rock were handled in excess of what the coal would normally contain. At a price of \$2.50 f.o.b. mine and a freight rate of \$1.50 per ton, the consumer has paid \$120,000,000 for worthless material. The additional cost of firing this coal, repairing furnaces, stoker and locomotives and the cost of handling the ashes, will add some millions of dollars more.

The coal consumer today is obtaining not only a poorer grade coal than formerly but a coal much more difficult to burn efficiently, due to increased content of sulphur balls, slate and bone. Not only is this true, but a big variation in the quality of coal leads to further inefficiencies. Stoker practice and our present settings are largely designed for a particular type of coal of a certain grade. The flexibility of such equipment in handling efficiently considerable variations in quality of fuel and nature of ash is limited. Under such conditions powdered coal by reason of its characteristics as a fuel offers us in many cases a solution of the problem.

#### BURNING LOW-GRADE FUELS IN SUSPENSION

In burning low-grade fuels in suspension the only loss in efficiency is that due to lower flame temperature caused by the increasing amount of ash and the heat lost in the ash. Coals running as high as 30 to 40 per cent ash can be successfully burned; combustion will be complete and maximum flame temperature for that fuel will be obtained. The only difference between burning a fuel of

this type and a high-grade fuel is the difference in flame temperature and the heat loss in the slagged ash. An ash whose slagging character would lead to enormous difficulties in producer or stoker operation will simply melt the easier when the coal is burned in powdered form and can therefore be dropped out earlier in the furnace, which in many cases constitutes an actual advantage. The lignite fuels of the Middle West and the Far West can be burned successfully and are being burned successfully in powdered form. An enormous field is opened up through ability to burn with efficiency these lower-grade fuels. It will eliminate long hauls of fuel by our railroads, release motive power and cars, and conserve our fuel reserves.

An unusually good illustration is found in two coals previously mentioned, one a Virginia coal more than 14,000 B.t.u. and less than 6 per cent ash, and the other a Colorado coal. Both of these are practically unavailable as fuels when using stokers, grates or producers, because of the chemical nature of the ash and its mechanical form. When, however, these coals are pulverized, the distribution of the ash in the lump coal has no effect, while the low melting-point of the ash in many cases offers a decided advantage. These coals both afford splendid fuels of high heating value when burned in powdered form. The Colorado fuel is being burned successfully this way. The River Smelting and Refining Company which is burning this Colorado fuel has cut the fuel requirements per ton of ore smelted in a reverberatory to  $\frac{1}{2}$  that necessary when this coal was burned on grates.

It has been the object of this paper to discuss the unusual characteristics of powdered coal as a fuel; not only the characteristics of the fuel before being burned, which of necessity dictate the principles which must be made use of in designing proper equipment and which give us an idea of the possibilities offered by this fuel, but its more striking possibilities have been shown. Many of these are actually being obtained commercially today. From your knowledge of your own industries, no doubt many other possibilities will suggest themselves to you.

Chicago, Ill.

**Gasoline Recovery from Natural Gas.**—Gasoline recovery from natural gas by compression and refrigeration has been systematically treated in *Bulletin* 151, Bureau of Mines, by W. P. DYKEMA. Conditions of actual operation and the equipment in use are described. The vapor pressure of gasoline being relatively low compared to that of marsh gas, etc., it has been found that the percentage content of gasoline decreases greatly with high pressure, so that the most favorable sources of supply are low pressure gas wells. Up to five or six years ago, coils were used by most operators in compressing 200,000 to 300,000 cubic feet daily. The gas used yielded from four to six gallons of gasoline per 1000 cu.ft. of gas. At present, plants are in operation having multiple compression with elaborate cooling effects, in which as much as 9,000,000 cu.ft. of low-grade gas is used having only one gallon of gasoline per thousand cubic feet. From 100 to 300 barrels of water are required for cooling 1,000,000 cu.ft. of gas at 250 lb. per square in. working pressure per day.

## Chemical and Metallurgical Notes from Japan

BY KATSU YASUI

### POTASSIUM CHLORATE

Prior to the present war, there was only one factory manufacturing potassium chlorate in Japan, with an electric power consumption of 2850 kw. hr. According to late government reports, the number had increased to seventy factories in August, 1917, with a power consumption of 14,000 kw. hr.

### MATCHES

Instead of being one of the chief imports to the Orient, matches have now become one of the principal exports (of Japan), a trade being even established in America. The statistics for last year are:

|                   | Cartons     | 12 Boxes | Value      |
|-------------------|-------------|----------|------------|
| Common match      | 445,112,000 |          | 11,662,000 |
| Yellow phosphorus | 146,372,000 |          | 1,974,500  |
| Specialties       | 15,870,000  |          | 267,500    |
| Total             | 607,321,000 |          | 13,904,000 |
|                   |             | Cases    |            |
| Exports           | 41,321,000  |          | 10,551,500 |

The price of matches has advanced with the general rise in raw materials. The average price per carton and the total value of the yearly production have been compiled as follows:

|      | Per Carton | Value of Production |
|------|------------|---------------------|
| 1912 | \$0.13     | \$7,073,000         |
| 1914 | .16        | 7,722,000           |
| 1915 | .23        | 11,385,000          |
| 1917 | .27        | 13,904,000          |

### NITROGEN

The government has made a large appropriation of money to help create a domestic nitrogen industry, in recognition of the indispensability of nitrogen products for agriculture, industry and ordnance. The statistics for local production in tons are:

|                          | 1913  | 1914   |
|--------------------------|-------|--------|
| Ammonium sulphate (tons) | 7,400 | 15,900 |
| Calcium cyanamide (tons) | 2,500 | 5,000  |

The imports in 1913 were:

|                   | Tons    | Value       |
|-------------------|---------|-------------|
| Ammonium sulphate | 110,000 | \$8,000,000 |
| Sodium nitrate    | 26,500  | 1,450,000   |

About 60 per cent of the sodium nitrate was used in industrial and explosive works, the remainder, for agriculture. During the war, the demand has been three-fold times as great and the supply very inadequate.

### TIN PLATE AND CANS

The Nitto Steel Manufacturing Co. of Kawasaki, near Tokyo, has increased its capital to \$2,500,000, and has started the construction of a tin-plate department with a capacity of 15,000 tons per annum. The Oriental Can Manufacturing Co. has placed orders in the United States for can-making machinery and is waiting for delivery which is very slow because of the present scarcity of ships.

### HIGH-SPEED STEEL

The Japan High-Speed Steel Works, near Tokyo, which was founded by Mr. Totaro Ezaki, is being greatly enlarged and will have 40 rolling mills and steam hammers. Capital \$1,500,000.

### CYANIDE AND MERCURY IMPORTS

|                    | 1915      | 1916      | 1917      |
|--------------------|-----------|-----------|-----------|
| Potassium Cyanide: |           |           |           |
| Quantity (tons)    | 330       | 513       | 246       |
| Value              | \$181,896 | \$324,578 | \$195,337 |
| Sodium Cyanide:    |           |           |           |
| Quantity (tons)    | 175       | 270       | 270       |
| Value              | \$82,175  | \$138,348 | \$161,970 |
| Mercury:           |           |           |           |
| Quantity           | 137       | 284       | 200       |
| Value              | \$216,693 | \$639,674 | \$464,691 |

### ORES MINED

|           |                 |
|-----------|-----------------|
| Gold      | 1,554 oz.       |
| Silver    | 41,800 oz.      |
| Copper    | 8,400 tons      |
| Iron      | 7,573 tons      |
| Coal      | 1,815,637 tons  |
| Sulphur   | 5,242 tons      |
| Petroleum | 160,000 barrels |

### CHEMICAL MANUFACTURING CENSUS

| Industry            | No. of Factories | Employees |
|---------------------|------------------|-----------|
| Ceramic             | 962              | 49,293    |
| Paper               | 277              | 21,309    |
| Lacquer             | 5                | 192       |
| Leather             | 48               | 3,968     |
| Powder              | 255              | 31,177    |
| Oil and wax         | 74               | 4,619     |
| Pharmaceutical      | 183              | 9,281     |
| Rubber              | 99               | 8,178     |
| Toilet goods        | 21               | 1,021     |
| Color, paint, paste | 69               | 2,695     |
| Fertilizer          | 58               | 6,277     |
| Miscellaneous       | 63               | 4,049     |
| Total               | 2,146            | 143,631   |

### MOLYBDENUM

Molybdenum ores have been found at Gifu Prefecture, Onari-gun; Toyania Prefecture, Shinkawa-gun; Niigata Prefecture, Kambara-gun; Totori Prefecture, Nogi-gun and Ohara-gun; and Hyogo Prefecture, Shishikuri-gun. While only 5.6 tons were mined in 1914 and 11.1 tons, in 1915, the output is expected to increase greatly, making Japan one of the prime producers of molybdenum.

### Trained Men Wanted by Bureau of Mines

Important chemical and other technical engineering work necessary for the prosecution of this war is being carried on by the Bureau of Mines Experiment Station, at Washington, D. C. The services of trained men of the following classifications are urgently needed:

|                                      |                                |
|--------------------------------------|--------------------------------|
| Bacteriologists                      | Instrument Makers              |
| Biologists                           | Laboratory Assistants          |
| Chemists, Inorganic                  | Laborers                       |
| Chemists, Organic                    | Machinists                     |
| Chemists, Physical                   | Physiologists                  |
| Chemists, Electro-chemical Engineers | Plumbers                       |
| Draftsmen                            | Steamfitters                   |
| Electrical Engineers                 | Stenographers                  |
|                                      | Skilled labor of various kinds |

If your training fits you for any of these occupations, send to the

Bureau of Mines,  
American University Experiment Station,  
Washington, D. C.

for blank forms. When properly executed and returned by you, these forms will be placed on file, and when a vacancy occurs you will be considered for it and will be notified if your services are desired.

If you are a registrant in the draft, and have not yet been ordered to camp, it may be possible to have you immediately inducted into the service for work here. If you are not in the draft, but feel that you wish to serve your country in the present crisis, you can enlist, or serve as a civilian.



## Synopsis of Recent Metallurgical and Chemical Literature

**Occluded Gases in Ferrous Alloys.**—The February, March and April *Journal* of the Franklin Institute contains an important contribution on the above subject by GELLERT ALLEMAN and C. J. DARLINGTON of Swarthmore College. The first part of the paper contains an extensive review of the literature, showing the extremely various results and views attained by individual investigators. Troost and Heutefeuille in 1873 concluded that gas bubbles formed on solidifying metal were forced out of solution on cooling. Parry in 1881 found that his former results were somewhat in error owing to the fact that the iron carbide in the metal reacted with the silica of the container, giving carbon monoxide gas and a high silicon alloy. This fact was controverted by Baker (1909) but re-established by the present authors. Parry's results were received with much skepticism on account of the large volumes of gas obtained—up to 340 volumes. Poursel in 1882 investigated the effect of various ferro-alloys in reducing the number of blowholes in steel ingots, and concluded that aluminum or silicon steel contained no gas if no manganese were present, but 2 per cent manganese occluded large quantities of hydrogen. Henry M. Howe (1892) wrote that the gases nitrogen, hydrogen and carbon monoxide dissolve in molten iron and their escape is what causes blowholes. Braune (1903-1906) concluded, however, that nitrogen was present as nitride, probably  $\text{Fe}_3\text{N}_2$ , and its presence could be detected microscopically by observing the increase in crystalline structure of the ferrite grains, closely resembling uniform pearlite on high nitrogen contents. von Malitz (1907) concluded that heating melts to a very high temperature diminishes the tendency of iron to absorb hot gases, but Sieverts (1910) found the opposite. Boudouard (1907) found that evolution of gases commenced in all cases at a red heat, while repeated heatings did not entirely remove the gas. He also records that volatilization of the iron commences at 900 deg. C. and is very noticeable at 1100 deg. C. Baker (1909) concluded that mechanical work diminished the volumes of the evolved gas some 50 per cent. He failed to find the appreciable dissociation pressure to be expected if the gas were due to the decomposition of ferrous compounds, and therefore thought that the gas was imprisoned as such in the pores of the steel, to be driven out on heating in vacuo. On the other hand Heroult (1910) and Goerens (1910) say that cold steel of any manufacture does not contain any appreciable amount of gases, blowholes being formed largely by carbon monoxide produced by reaction between carbides and oxides. Sieverts (1910) found that nitrogen was absorbed by gamma iron only.

### HYDROGEN OCCLUDED INCIDENTAL TO ELECTROLYTIC ACTION MAKES IRON BRITTLE

Large quantities of hydrogen are occluded by iron incident to electrolytic action, making it very brittle. Roberts-Austin (1899) thinks that a critical point of

481 deg. C. is due to the formation of a hydride, and another at 261 deg. C. of an eutectic. Iron in an acidulated solution absorbs hydrogen at a point lower than the decomposition voltage, using up chemical energy to change the molecular structure of the iron.

The present authors think that these divergencies are largely due to the porosity of the containers at high temperatures, allowing infiltration of air and flame-gases, and also to the fact that the heating was not sufficient. Preliminary experiments indicated that quartz tubes reacted with the metal, rapidly devitrified and became porous. Special alundum tubes, 1 in. diameter and 24 in. long, were consequently wound for 5 in. with 20 ft. of No. 20 molybdenum wire, plastered with alundum cement and wrapped with two layers of asbestos rope. This tube was centered into a welded iron jacket, 8 in. diameter by 10 in. long, entering through 2 in. nipples at each end. The joint at this point is sealed with alundum cement, wound with okonite tape and covered with rubber cement. The whole protruding ends are then covered with a glass bulb, one of which is connected with an air pump. The heating current is led in through the iron casing by two iron bolts cemented into flanged openings by alundum cement and rubber stoppers, on the outside of which were layers of bakelite and rubber cement. It is absolutely necessary that a vacuum as complete as possible be maintained in a perfectly gas-tight container, else the molybdenum wire will burn readily. With this apparatus a temperature of 1800 deg. C. may be gradually attained and maintained for 5 minutes.

### HYDROGEN LARGEST CONSTITUENT OF GAS EVOLVED AT 950 DEG. C.

Experimenting with iron wire at about 950 deg. C. they found hydrogen to be the largest constituent of the gas evolved, no oxygen or carbon monoxide being found. Basic open hearth steel (1.05% C) evolved 198 volumes of gas after 35-hours heating in a quartz tube at from 940 to 1470 deg. C., the gas consisting of 60 per cent carbon monoxide, while another sample more rapidly heated gave a mixture containing 80 per cent  $\text{CO}$ . Bessemer steel (0.08 C) heated 23 hours at 1100 deg. C. evolved 55 volumes of gas consisting largely of hydrogen. The same steel heated in the improved furnace in an alundum boat evolved 220 volumes of gas of the following analysis:

| Gas                  | At 1,000° C. | At 1,250° C. | At 1,500° C. | At 1,675° C. |
|----------------------|--------------|--------------|--------------|--------------|
| Illuminants.....     | 0.00         | 0.00         | 0.00         | 0.00         |
| Carbon dioxide.....  | 1.08         | 0.62         | 0.00         | 0.00         |
| Oxygen.....          | 2.4          | 3.07         | 4.28         | 6.25         |
| Carbon monoxide..... | 48.9         | 56.10        | 18.75        | 8.42         |
| Hydrogen.....        | 21.16        | 15.08        | 4.20         | 1.10         |
| Nitrogen.....        | 26.46        | 25.13        | 72.77        | 84.23        |
| Total.....           | 100.00       | 100.00       | 100.00       | 100.00       |

The authors conclude that the gases are mostly evolved from interaction of iron oxides, nitrides, carbides and hydrides, certain of which exercise deleterious effects on the steel, and the removal of which will show marked change in microstructure and increase in density. Hydrogen is most readily freed, carbon monoxide next, and nitrogen is held tenaciously. So-called deoxidizers may act as a catalyst to prevent occlusion of gas at high temperature or promote its elimination at lower.

## Recent Metallurgical and Chemical Patents

**Denitration of Sulphuric Acid.**—INGENUIN HECHENBLEIKNER, of Charlotte, North Carolina, patents the process and apparatus of denitration of sulphuric acid together with the oxidation and hydration of the nitrogen oxides in one operation, recovering thereby a pure nitric acid. As shown in Fig. 1, he introduces nitrified acid from tank 13 through the distributor, whence it trickles through the tower-filling against rising steam introduced through pipe 11. The nitrous

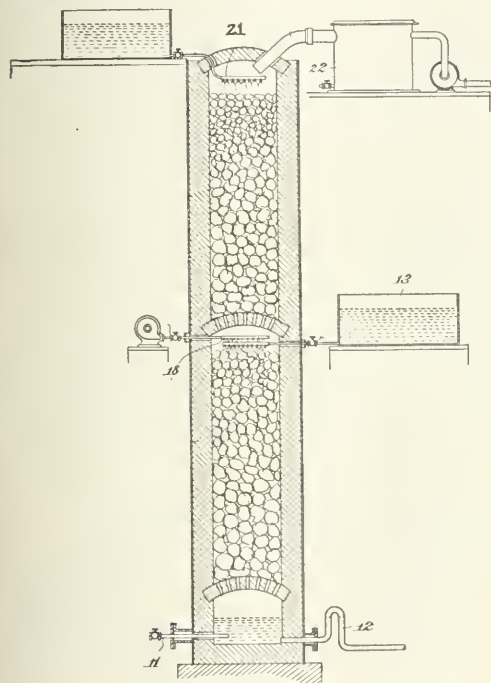


FIG. 1—DENITRATION OF SULPHURIC ACID

gases thus driven out by the steam are oxidized and hydrated to form nitric acid by the oxygen blown in through distributor 18, oxidation being particularly rapid in the presence of ozonized air. As a great amount of steam must be utilized for denitration concentrated sulphuric acid is showered through the distributor head 21 in the upper part of the column for the purpose of removing part of the water contained in the nitric acid fumes. Concentrated sulphuric acid is preferably used because it possesses manifest advantages for drying nitric acid fumes which contain a relatively great amount of surplus steam. Furthermore, the sulphuric acid thus added equalizes the concentration of the denitrated sulphuric acid escaping through the siphon 12, since denitration cannot be completed if the concentration of the sulphuric acid is less than 60%, while for practical purposes the

best denitration can be accomplished by a concentration of between 60 and 70% sulfuric acid. The dry nitric acid vapor is drawn into the condenser, conventionally represented at 22, where the pure material is recovered. (1,264,512; assigned to the Southern Electro-Chemical Co., April 30, 1918.)

**Process and Apparatus for Concentrating Acid.**—INGENUIN HECHENBLEIKNER of Charlotte, North Carolina, patents the apparatus for producing 98 per cent sulphuric acid shown in Fig. 2, together with the process of operation. The weak acid is introduced at the top of the tower 10b, and trickles down through the acid proof filling against a counter current of hot gases. A fan drives air through the bustle pipes 5 and tuyeres 7 into the bath of acid. The air is previously heated to about 400 deg. C. by gas or oil burners at the ends of the fire-brick lined pipes 5. The heated air agitates the bath and absorbs water at a temperature below the boiling point of the acid,

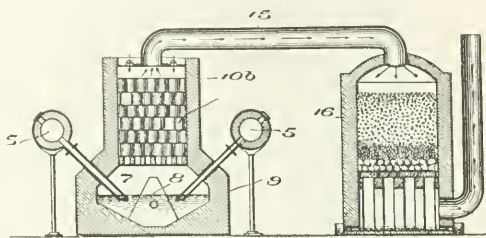


FIG. 2—CONCENTRATION OF SULPHURIC ACID

issuing at the surface of the acid at a temperature of about 200 deg. C. This heat is largely transferred to the descending droplets of weak acid in the checker-work above. In order to catch the last trace of acid in the cooled gases exhausting through pipe 15, a condenser 16, filled with acid-proof material is employed. The weak acid recovered here is drawn off from the air seal bottom, as is also the concentrated acid from the bath 8. By removing the moisture without boiling the acid no substantial loss in acid is experienced, while the method is also claimed to utilize heat very efficiently. (1,264,509; assigned to Southern Electro-Chemical Co., and 1,264,182; April 30, 1918.)

**Separation of Potassium Salts.**—GUY STERLING, of Salt Lake City, Utah, patents a process for recovering a mixture of potassium and sodium salts from the mother liquors of natural brines which usually contain a large amount of magnesium salts. He mixes about 0.8 parts by weight of the mother liquor salts with 0.5 parts of silica, and 0.85 parts of limestone, all finely powdered. He then heats the mixture to about 1400 deg. C. for three hours, stirring the mass, when the potassium chloride, potassium sulphate, and sodium chloride largely sublime, leaving behind a complex calcium-magnesium-sodium-silicate. A magnesium-free concentrate is thus produced. (1,264,572; Apr. 30, 1918.)

**Production of Percarbonates.**—OTTO LIEBKNECHT, of Frankfort-am-Main, Germany, patents the process of precipitating percarbonates from hydrogen peroxide sodium carbonate solution with excess of sodium chloride. (1,263,258, May 21, 1918.)

**Pulverized Fuel Burner.**—T. B. CRAM, of Chicago, Ill., patents the burner illustrated in Fig. 3, whereby a short, hot flame may be had when burning pulverized coal. Air enters through pipe 8, a portion of which passes through nozzle 17, sheathing a jet of pulverized coal entering through pipe 16 with a layer of cold air travelling at a considerably higher velocity. This

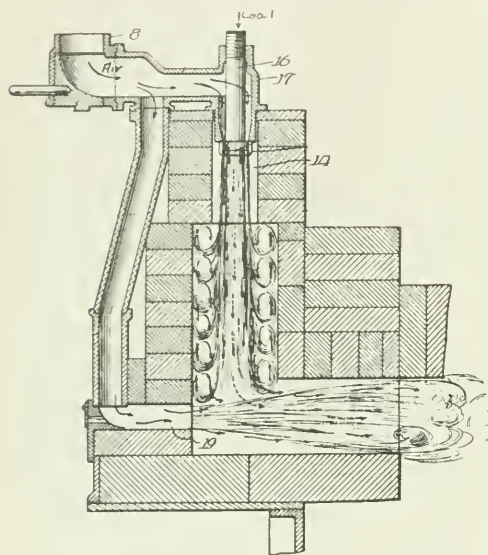


FIG. 3—PULVERIZED FUEL BURNER

sheath keeps the metal parts and the upper opening 14 cool and free from flame and at the same time sets up a swirling motion as indicated in the vertical combustion chamber. The fuel ignites and partially burns in this chamber, at the lower part of which it meets at an angle a stream of air coming through pipe 19 containing sufficient oxygen for completing the combustion, which is effected immediately in a short, hot, and smoke-free flame. (1,258,654; Mar. 12, 1918. Assigned to Railway Materials Company.)

**Agglomerating Oxidized Ores.**—A. S. DWIGHT, of New York City, patents a method of utilizing the familiar Dwight-Lloyd roaster for the agglomeration of oxidized material, especially iron ores. He notes that the formation of silicates so desirable when sintering sulphide ores must be avoided in a treatment of oxidized ores preliminary to their being smelted. He therefore feeds a well mixed stream of ore, carbonaceous material and flux on the pallets. The carbonaceous material is ignited and its combustion sufficiently heats and reduces the oxidized ores that the various basic oxides form compounds below the temperature of silicate formation. The ore mixture is spread in a thin layer so that the heated gases readily escape without the formation of hot pockets where silicates might be formed. A sufficient excess of carbon is placed in the original mixture so that at the end of the process enough will remain to complete the reduction to metallic state on further smelting. (1-254,316; Jan. 22, 1918.)

**Chromium Compounds of Azo Dyes.**—RENE BOHN and PAUL NAWIASKY of Germany have found that chromable azo coloring matters containing at least one hydroxyl and one sulphuric acid group can be made to yield soluble chromium compounds by being heated with a chromium salt in the presence of water. It is equivalent whether the free sulfonic acid or hydroxyl groups or a salt of such groups be present. The azo coloring matters which are derived from ortho-amino-phenols or ortho-ammino-naphthols or anthranilic acid or benzidine disulphuric acid or toluidine disulphonic acid or from a derivative of any one of these compounds are useful for this purpose whereby in particular salicylic acid and derivatives thereof may be employed as the other component. The new compounds are soluble in water and have an intense color and can be applied for printing purposes, the compounds thus obtained being better and more completely fixed and consequently faster than the prints obtained by applying the chromable azo coloring matter in the presence of a chromium salt to the fiber. The new compounds, after being printed on the fiber, can be fixed by means of alkaline reagents, such for instance as sodium carbonate, or ammonia, and thus differ from the mere mixtures of chromable azo compounds and chromium salts which cannot suitably be fixed by such a process. Four examples of the process are described in detail. (1,264,604; Apr. 30, 1918; Assigned to Badische A. & S. Fabrik.)

**Burner for Dwight-Lloyd Roaster.**—S. E. FRASER, of Port Pirie, South Australia, patents an improved burner for igniting the ore stream on a Dwight-Lloyd roaster shown in Fig. 4. It comprises a number of special refractory bricks strongly bound together with iron bars and rods and shaped to form a shallow, inverted elliptical dish. Blow torches 8 introduce a

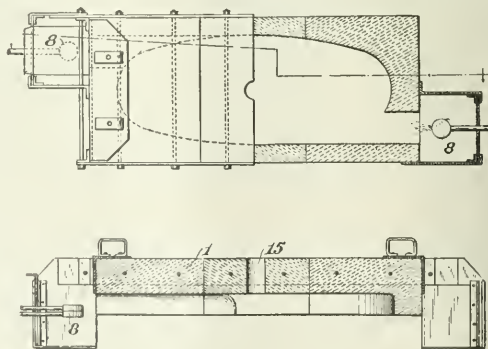


FIG. 4—PLAN AND ELEVATION OF DWIGHT-LOYD ROASTER

flame tangently, and in operation the dish is filled with a swirling flame playing above the moving ore stream, heating by contact and radiation from the incandescent brick dish. Additional air may be introduced through openings like 15 as necessary. (1-262,580; Apr. 9, 1918.)

**Extraction of Resins and Turpentines.**—DAVID J. OGILVY, of Cincinnati, Ohio, patents an improvement over the usual methods for the extraction of resins



by digestion of woods with such solvents as petroleum distillates, pine oils, turpentine, etc. He employs a digester practically filled with conifer chips which is connected to a still set at a lower elevation and filled with a mixture of resin solvent and water. This mixture is heated and its vapors enter the bottom of the digester, extracting the resins, oleoresins and turpentine in the wood, which extracts are carried back into the still in the return condensate through the connection pipe. A reflux condenser is placed above the extractor to catch the uncondensed water and solvent passing up through the wood contained in the digester. When the operation is completed, the still containing the watery liquid and the resinous magma is connected with an exhaust condenser and a preliminary separation made of the resin solvents, turpentine and oils. The resinous magma and watery liquor remaining in the still are separated and the magma used for the production of resinous substances. The inventor claims that his process may be conducted at a lower temperature, and the continual presence of water vapor is an additional precaution against fire and explosion. The water and steam have a disintegrating action on the wood, allowing readier attack of the solvent, which itself is attenuated and used to maximum efficiency by the same agents. (1,264,551; April 30, 1918.)

**Arc Adjustment in Steel Making.**—WM. E. MOORE, of Pittsburgh, Pa., notes that it is desirable to use a long arc when melting solid metal in an electric furnace. This long arc gyrates over a large area, and local short circuits by molten metal are therefore not so troublesome. The high heat of such an arc is not particularly damaging to the furnace roof, since the unmelted metal absorbs radiations much more completely than after it is covered with a glassy slag. During the refining process, therefore, it is preferable to shorten the arc considerably. The inventor proportions the electrical circuits for the low voltage arcs of the refining cycle, and increases the voltage only during the melting stage, from say 40 or 60 volts up to 120 or 240. This practice reduces the size of the electrical conductors, switches, and other accessories, as well as bettering the power factor by reason of less self-inductance and counter electromotive force. The inventor also utilizes the rectified current produced during the furnace operation to heat the bottom just sufficiently to prevent formation of accretions and to stir the bath. He presents a number of wiring diagrams for different conditions of current and arrangements of electrodes. (1,242,464; Oct. 9, 1917.)

**Coke Oven.**—THEODOR VON BAUER of Germany patents a new coke oven constructed to operate on the regenerative principle and so arranged with combined

vertical and horizontal flues that the heat can be increased from the top of the retort downward. This prevents decomposition of the valuable by-products in their passage through a previously coked portion of the charge, and provides an increased heat for the denser bottom portions. In Fig. 5 preheated air from regenerator *u'* and gas from the main de enter the top horizontal flue *e*, passing into flue *g* through vertical passes *f*. Here the burning gases are mixed with more air and gas introduced through the heads of the oven walls. Entering flue *i* the hot gases receive further supplies of air and gas through a number of openings leading downward from a double channel *h*. In order to simulate surface combustion conditions, these gases—now containing an excess of combustible,

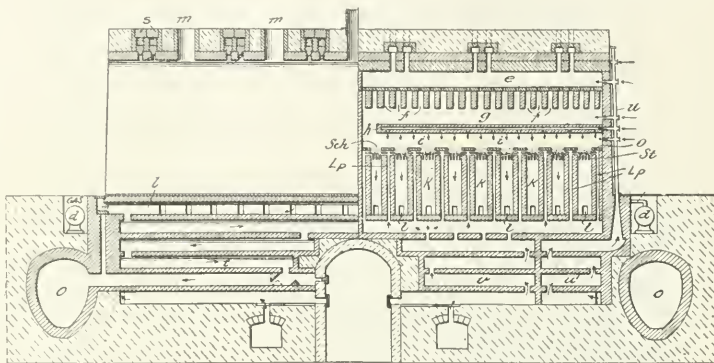


FIG. 5—REGENERATIVE COKE OVEN

pass into vertical flues *k* through the mass of broken chamotte *Sch* supported by perforated stones *St*. During this passage they receive the necessary air for combustion from the vertical flues *l* which conduct preheated all from regenerator *v* to the mass of chamotte. The hot gases then enter a sole channel *l* by the ports at the base of the vertical flues *k*, and thence pass through the regenerative flues *t* to the main culvert *C*. The inventor

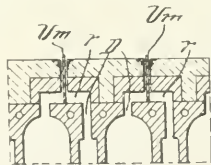


FIG. 6. FLUES

points out that the oven may be connected to a by-product plant during the early part of the distillation in the usual manner, but as the gases evolved became leaner in valuable hydrocarbons, it may be conducted directly into heating flues *e* at either side of the chamber by the double row of staggered passages *s* placed between each charge hole *m*. Figure 6 shows one set of these flues; when the lean gas is to be burned without cleaning, the slide gates *Vm* are raised. (1,253,445; Assigned to Bernhard Zwilling of New York City; Jan. 15, 1918.)

**Air Distribution in Regenerative Checkerwork.**—J. E. HUBBELL, of Philadelphia, Pa., patents an improvement in coke ovens with vertical heating flues and with regenerators set longitudinally below, designed to preheat the air only. Each unit of the regenerator contains a double sole flue, one for withdrawing the

waste gases during the heating stage, and the other contains an air pipe perforated at intervals along its length which acts as a distributor when cold air is flowing upward. By proper design a very uniform flow of hot air may be admitted into each of the heating flues above the regenerator, there to combine with gas entering through a nearby nozzle. (1,254,007, Assigned to Louis Wilputte, New Rochelle, N. Y., Jan. 15, 1918.)

**Ore Cooling, Moistening and Feeding Table.**—A. H. RICHARDS, of Salt Lake City, Utah, patents the device shown in Fig. 7 for converting an intermittent feed from furnace or elevator into a continuous stream. The material, which may be hot, drops through hopper 9 near the center of the rotating plate 10, and is

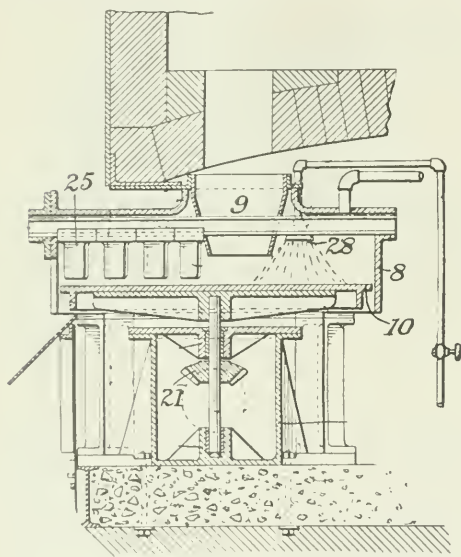


FIG. 7

gradually mixed and worked to the outer edge by the rabbles 25. Opposite these rabbles is a water spray 28, allowing the ore to moisten and cool one half rotation before reaching the rabble blades. The whole is surrounded by a proper hood 8 and the plate is supported by a shaft passing through the enclosed gear box 21 of sufficient stiffness that rollers under the edge of the horizontal plate are unnecessary. (1,231,790; Assigned to American Smelting and Refining Co., July 3, 1917.)

**Refractories.**—R. R. ZELL, of Birmingham, Ala., patents the use of a local mineral product called "siliconite" in the manufacture of refractory brick. Siliconite is finely divided silica, probably formed by weathering of earlier deposits, and contains but small traces of lime and magnesia, and about 2.25 per cent of iron and aluminium oxides. This mineral is crushed and a properly sized product mixed with 5 per cent of aluminium hydrate, 5 per cent of dehydrated gypsum and moistened into a plastic mass with a 10 per cent caustic potash solution. The mass is then wet-pressed, baked at 500 deg. F., and is then ready for the mar-

ket without further burning. (1,244,275; assigned to Siliconite Refractories Co., Oct. 23, 1917.)

F. M. BECKET, of Niagara Falls, N. Y., patents the use of ordinary or special slags produced in the ferro-chromium furnace. These slags are essentially a  $MgO \cdot Al_2O_3 \cdot SiO_2$  complex containing lesser percentages of iron and chromium and their oxides. After crushing and sizing, the mass is moistened with water or dilute sodium silicate, shaped in a brick press, and air or furnace-dried at temperatures as required by the contemplated use. The moist mixture may also be tamped in place in the furnace and fired. This refractory has a low coefficient of expansion, a high heat conductivity, high softening point, and very resistant to alkalis and basic slags. (1,244,688; Assigned to Electro Metallurgical Co., Oct. 30, 1917.)

FRED A. JONES, of Lakewood, Ohio, notes that calcined dolomite cannot be used for repairing furnace linings as a substitute for calcined magnesite owing to the fact that the calcium oxide contained in the former tends to air-slack, reducing the lumps to a fine powdery material which will be swept out of the furnace by the draft. He proposes to protect the dolomite from moisture by covering each particle with a layer of slag. He crushes the dolomite to about  $\frac{1}{4}$  inch, and mixes it with 10 per cent by weight of flue dust—essentially fine iron ore, coke, and limestone—when the whole is suitably moistened and calcined at from 2000 to 2500 deg. F. in a rotary kiln. In this manner the  $CO_2$  is driven from the dolomite, and a thin film of impervious material fuses on the outside of each particle. Finely divided materials of the same nature when calcined as noted will produce agglomerated particles of substantially the same properties. (1,251,535; Jan. 1, 1918.)

**Electric Furnace Processes for Iron and Steel Manufacture.**—ERNEST HUMBERT, of Welland, Ontario, patents the process of making steel or pig iron by placing scrap irons of various origin in a hot electric furnace together with a predetermined amount of coke and flux. As soon as the lower portion of the solid charge attains incandescence, air is blown into the mass by a pipe, projecting downward through a door, and the end of the pipe adjusted from time to time so as to be kept just above the pool of melting metal. The inventor claims that the air blast removes the impurities very rapidly, and the melting time is largely reduced; the heat ends with refined, hot metal free from iron oxides ready to pour in from  $\frac{2}{3}$  to  $\frac{1}{2}$  the time of the older processes using electric energy only, with a corresponding increase in furnace and electrode capacity and life. (1,242,442, Oct. 9, 1917; and 1,252,443, Jan. 8, 1918.)

SAMUEL McDONALD, of Alhambra, Cal., patents the process of manufacturing steel in a tilting furnace, containing molten iron or steel, covered with a layer of molten iron ore. Downwardly inclining tuyeres in the rear blow a carbon-laden gas into the mixture at various depths, as the operator wills, by tilting the furnace. The carbon is absorbed by the steel, there to reinforce the reducing action of unabsorbed carbon on the molten oxide laying above and mixed into the metal by the stirring action of the blast. (1,255,191, Feb. 5, 1918.)

## Porcelain Pots for the Melting of Optical Glass

THE corrosive action of optical glass-melts and the high temperatures required to fuse them make it necessary to use pots both resistant to the action of the fused mass and sufficiently refractory to withstand the severe heat duty. At the same time it is desirable that the iron content of the pot mixture be so low that practically no contamination of the glass through this source occurs. This is particularly advisable in the fusion of barium glasses which are sensitive to the presence of iron oxide and readily assume a green color which is detrimental for photographic purposes. Since decolorizing is not permissible in making optical glass the importance of pure constituents and of pots as low in iron as possible is obvious. Experience has shown that the commercial pots are not suited for this work. The optical glass laboratory of the Bureau of Standards at Pittsburgh has realized the importance of special pots from the beginning of this work several years ago and has completed a series of experiments with the result that a mixture has been produced which resists even the extremely corrosive action of heavy barium crown glass, which so far has been found to destroy every kind of pot in which attempts have been made to melt it.

The composition in question is virtually a porcelain and in using the pots it is necessary to carry the temperature to about 1400 deg. C. before they are charged with the glass mixture. This will insure the vitrification of the body and with it the desired dense structure.

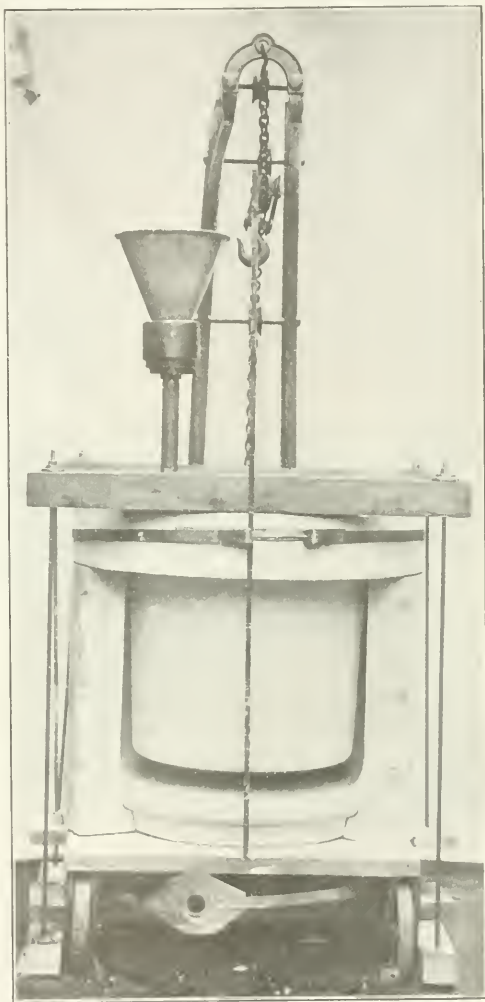
The composition which has given the best results is as follows:

|                                                                               | Per cent |
|-------------------------------------------------------------------------------|----------|
| White-ware pottery bisque, ground and screened to pass the 10-mesh sieve..... | 35       |
| Pot shell (from used porcelain pots).....                                     | 10       |
| Feldspar.....                                                                 | 3        |
| Potters flint.....                                                            | 4        |
| Tennessee ball clay.....                                                      | 15       |
| Illinois bond clay.....                                                       | 5        |
| Georgia kaolin.....                                                           | 8        |
| Florida kaolin.....                                                           | 8        |
| North Carolina or Maryland kaolin.....                                        | 12       |
|                                                                               | 100      |

The pottery bisque is the waste unglazed material which is rejected in the manufacture of white tableware. The supply of this bisque is ample for the needs of the pot makers supplying the optical glass manufacturers. For the purpose in question it is necessary to use only the so-called white-ware body and not porcelain, whether it be for table-ware, floor tile or electrical insulators which would not be sufficiently refractory.

At the Pittsburgh laboratory of the Bureau of Standards the production of glass pots by the casting process has also been developed very successfully, thus eliminating the use of skilled labor needed in making the pots by the usual building-up method. Here the body constituents, to which about 0.2 per cent of a mixture of sodium silicate and sodium carbonate has been added, are prepared to a thick but still fluid suspension which is poured into suitable plaster molds provided with a core. The plaster absorbs the water very readily and causes the mass to stiffen after about 16 hours when the core can be removed. The mold can be taken apart after about 24 hours. The pots thus

made have been found to dry very readily so that in many cases they can be placed in the furnace in from 4 to 6 weeks. This process ordinarily requires from



PLASTER MOLD FOR THE CASTING OF GLASS POTS

3 to 4 months. Cast pots have been made from the following composition:

|                                                 | Per cent |
|-------------------------------------------------|----------|
| White-ware pottery bisque, through 10-mesh..... | 48       |
| Tennessee ball clay.....                        | 15       |
| Illinois bond clay.....                         | 8        |
| Feldspar.....                                   | 5        |
| Georgia kaolin.....                             | 7        |
| Florida kaolin.....                             | 10       |
| North Carolina or Maryland kaolin.....          | 10       |
|                                                 | 100      |

The cast pots have proved very successful for the melting of optical glass and have been found to be superior to the hand-made ones owing to the uniformity of structure.



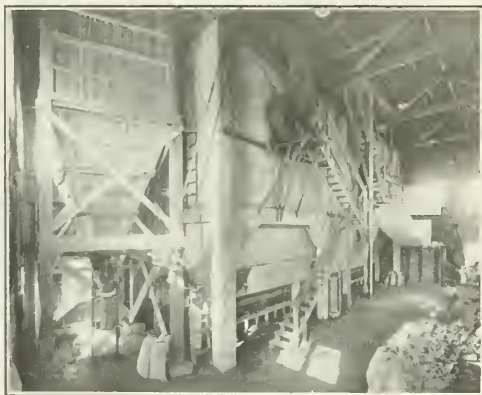
## A New Drying System for Liquids

**A**N interesting system for recovering the solid constituents of liquids in a dry, finely powdered form has been developed and is being introduced by Gerald A. Lough of 90 West St., New York. The system is simple and inexpensive and has been found very efficient.

The accompanying photograph shows one of these dryers installed in a tanning extract plant in Tennessee. The process is designated as the "air-blown process" and the equipment consists of a chamber constructed of masonry divided into two compartments, into the first of which the liquid to be evaporated is injected in a fine spray.

A current of hot air, furnished by direct-fire heating from the furnace at the right, is introduced below the spray, rises through it, absorbing its water content, and passes to the second, or dust-settling compartment. The bulk of the solid constituents of the liquid is deposited in the first compartment and the light flocculent particles in the form of fine dust in the second compartment.

A screw conveyor at the bottom of the chamber conveys the dried material from both compartments to a



EQUIPMENT FOR DRYING SOLUTIONS OR SUSPENSIONS

bucket elevator which raises the material to the storage bin at the left. From the bottom of this storage bin the material is bagged.

The advantages of the process are claimed to be low first cost and low upkeep, and considerable economy in drying owing in part to the fact that the heat is applied direct to the substance to be dried, and not by transmission through a metal membrane with consequent loss by radiation. The minute subdivision of the atomized fluid permits the heated air to surround each particle and absorb its watery envelope instantly. The liquid is projected into the chamber in such a way as to form a blanket of spray which fills the full transverse area of the chamber, so that to find an exit the hot air must pass through the spray and in consequence give up its heat.

Any product contained in solution, suspension or emulsion may be dried by this means to a fine, dry, flour-like product. Such substances as milk, eggs, malt extract and delicate chemicals may be reduced to their solid constituents by this means at high temperatures without

injurious effect. Whole or skimmed milk and eggs dried by this method are completely soluble in cold water.

The accessory apparatus—air heater, air compressor, motors, fan, dust collector and conveyors are all standard equipment, and the dryers are built on the job from plans designed for the customer's particular needs.

## Government Powder Plants Completed Ahead of Schedule

Operations in the Government's powder plants near Charleston, W. Va., and Nashville, Tenn., have begun two months ahead of schedule. The Nashville plant started June 4 and Daniel C. Jackling, Director of the United States Government Explosive Plants' Division, reported to Assistant Secretary of War Benedict Crowell that the Charleston plant started June 11. These two plants are beginning with the production of sulphuric and nitric acids, constituent parts in the manufacture of smokeless powder.

The \$120,000,000 allotted for the plants is expected to give the Government a smokeless powder production capacity equal to all other American plants combined. The War Department started preparations in the middle of January. A new division was organized, needs of the Army estimated and plans for the two plants were begun. As soon as sites were chosen, it was found necessary to build a new town on each site to house the employees. Approximately 9000 different buildings were erected. A staff of 500 engineers and architects laid out the plants.

Streets were put down and sewered, power plants constructed, and stores and hospitals erected. About 35,000 men worked on the construction of the plants. Probably 30,000 will be engaged in the actual production of powder.

When the task of building the plants was considered at the War Department last January, it was predicted that the production of powder might begin in August, barring unforeseen delays. Starting of the plants at this time insures their completion and full operation this year, or within less than twelve months of the date on which they were authorized.

## Importation of Chrome Ore and Chromite

In pursuance of the general policy of tonnage conservation, the War Trade Board have introduced restrictions upon the importation of chrome ore and chromite from overseas. The sources of home supply are numerous, and are believed to be capable of extensive development. To provide for interim demands, pending the further development of such deposits, imports from Cuba, Guatemala, Newfoundland and Brazil by sea will be permitted, not exceeding 43,500 tons up to March 31, 1919, and from New Caledonia up to 10,000 tons prior to December 31, 1918. Shipments overland or by lake from Canada, overland from Mexico, or as return cargo from European ports when coming from convenient ports and not involving delays in loading, will be permitted. All outstanding licenses for the import of chrome ore and chromite for overseas have been revoked as to shipments made after June 15, 1918.

## Book Reviews

**THE CHEMICAL ANALYSIS OF IRON**, by A. A. Blair, 313 pages, J. B. Lippincott Co., Philadelphia, Eighth Edition, 1918. Price \$5.00

The eighth edition of this well known work is presented in the same style as former editions. The old cuts have been used throughout with but few exceptions. The methods for the analysis of furnace and other gases have been omitted and a chapter added dealing with the analysis of alloy metals. Although the subject matter has been largely revised and rewritten the book is still open to some criticism.

In the introductory chapter descriptive of apparatus and reagents used in making iron analysis the classification of ammonium bisulphate,  $\text{NH}_4\text{HSO}_4$ , under "alkaline salts" and of barium hydrate under "salts of alkaline earths" will doubtless prove to be misleading to the beginner. In the chapter devoted to the determination of carbon by direct combustion it is disappointing to find no mention of the modern simplified methods in prevalent use and no illustrations of up to date combustion trains.

In the methods given for the determination of manganese mention has been omitted of the widely used titration with sodium arsenite of permanganic acid obtained by oxidation with ammonium persulphate in the presence of silver nitrate. The outline for the determination of nickel by titration with cyanide recommends an ether separation of the iron or the precipitation of nickel with dimethylglyoxime in place of the usual direct and rapid method of adding citric acid to eliminate the interference of iron.

The chapter on the analysis of alloy metals contains some excellent material. It is believed that this volume will be of more interest to the research chemist performing special analyses than to the routine steel works analyst. It contains some good outlines and will prove a valuable addition to reference libraries.

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**A TEXT BOOK OF INORGANIC CHEMISTRY**. Edited by J. Newton Friend, D.Sc., Ph.D. London: Charles Griffin and Company, Ltd.

**VOL. I: AN INTRODUCTION TO MODERN INORGANIC CHEMISTRY**. By J. Newton Friend, H. F. V. Little, and W. E. S. Turner. *THE INERT GASES* (Group O of the Periodic Table). By H. V. A. Briscoe, D.Sc. Second Edition, revised; large octavo (15 x 22 cm.), v + 385 pp.; price 10s. 6d. net (\$3.50 in U. S. A.).

**VOL. IV: ALUMINIUM AND ITS CONCENTRATIONS**, including the *RARE EARTH METALS* (Group III of the Periodic Table). By H. F. V. Little, B.Sc., Chief Chemist at Thorium, Ltd. Large octavo (15 x 22 cm.), xx + 485 pp., price 15s. net (\$5.00 in U. S. A.).

**VOL. V: CARBON AND ITS ALLIES** (Group IV of the Periodic Table). By R. M. Caven, D.Sc. Large octavo (15 x 22 cm.), xxi + 468 pp.; price 15s. net (\$5.00 in U. S. A.).

**VOL. VIII: THE HALOGENS AND THEIR ALLIES** (Group VII of the Periodic Table). By Geoffrey Martin, D.Sc., Ph.D., and Ernest A. Dancaster, B.Sc. Large octavo (15 x 22 cm.), xviii + 337 pp.; price 10s. 6d. net (\$3.50).

The title is something of a misnomer; the work is nearer to being a hand-book or small encyclopedia. It is similar in content to Moissan's "La Chimie Minérale." The plan is unique: each volume from I to IX takes up a successive group of the Periodic Table, thus bringing together in each volume the elements of one chemical family. Volumes II, III, VI, VII and IX are not yet issued.

Volume I is an up-to-date review of inorganic chemistry, followed by a 65 page section on the rare inert gases of Group O. There is not enough detailed explanation for a text-book, but it is a fine reference book, being particularly enriched by numerous foot-note references to the original sources of information. At places, however, the treatment is too scanty, e.g., the vapor pressure of solids is discussed in detail but not that of liquids; specific heats are handled

at length, but latent heat of change of state is not even mentioned. One suspects that there may be other omissions of important topics.

Volume IV on boron, aluminium gallium, indium, thallium, scandium, and the rare-earth elements is written in masterly style, particularly the second half devoted to the rare earths. Aluminium does not lend itself to condensed treatment as well as the other metals mentioned, and in this one instance the subject matter seems scanty and elementary; the other metals are relatively much more thoroughly handled, and in an entirely satisfactory manner which indicates the expert, master of his subject and enthusiastic in its presentation.

Volume V is concerned with carbon, silicon, titanium, tironium, thorium, germanium, tin and lead. The author was not equal to his task; in fact, he approached it with a dilettante air which spelled failure, he says in his preface "the group contains no element the study of which is quite so fascinating as that of, say, chromium or nitrogen; and, moreover, contains one element tironium, about which it would be difficult for any chemist to be enthusiastic." Starting with that totally unscientific attitude, an indifferent book followed of necessity; the author might have succeeded better if writing on chromium or nitrogen, but we have a right to doubt even that. The best chapter is that on thorium, and here the author had the assistance of Mr. Little, who wrote the fine treatise on the rare earths in Vol. IV, and who evidently keyed up this chapter to a proper scientific plane. The rest of the book is only "fair to middling."

Volume VIII appeared some time ago, and has already been reviewed in this *Journal*, Feb. 15, 1917, page 233.

The completion of the work as a whole will be a remarkable war-time achievement; the editor and publishers are to be congratulated on their enterprise and on the high average of success attained in the treatises.

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**THE THEORY AND PRACTICE OF ORE DRESSING**.

By Edward S. Wiard, S.B. Octavo (15 x 23 cm.), viii + 426 pages, 254 illustrations; price \$4.00 net. McGraw-Hill Book Company, Inc.: New York.

The scope of the work is narrower than its title. It concerns ore-dressing as applied in the western part of the United States. The treatment is unequal and in many places unsatisfactory. Five pages only to the oil-flotation process is practical exclusion from the book; three pages to electrostatic separation seems pretty scant; eleven pages to magnetic concentration is surely insufficient. These three important methods are all squeezed into one small chapter of twenty pages at the end of the book, whereas one would judge their treatment deserving of several times that space. The Dorr thickener is dismissed with two lines, without any further description; in fact, concentration altogether takes up less than one-fourth of the book, while crushing takes up over one-half. Yet the book has many strong points: crushing is well and thoroughly handled; theory is mixed throughout in a skillful and instructing manner; the practical descriptions are clearly written and well illustrated. With some of its deficiencies made up in a revised edition, it should prove a welcome book to the Western mill-man.

## Personal

MR. G. MONTAGUE BUTLER, University of Arizona, has just been appointed Director of the Arizona State Bureau of Mines to fill the vacancy created by the resignation of C. F. Willis. He will continue to serve as Dean of the College of Mines and Engineering, which position he has held for three years. The new Director of the Bureau intends to lay greater emphasis upon geological investigations, and will soon begin to collect the data required for the preparation of a reconnaissance geological map of Arizona.

MR. WILLIAM B. COLVER, chairman of the Federal Trade Commission, who has been in charge of wood pulp and its



products, including paper, has been extended additional authority over the same commodities by the War Industries Board.

ALEX. L. FEILD, formerly assistant metallurgist in the Bureau of Mines, has entered the research department of the National Carbon Co., Inc., in Cleveland, Ohio, and is engaged in general high temperature and physical research. During his service with the Bureau of Mines, Mr. Feild completed the very important investigations on viscosity of iron blast furnace slags.

MR. WALTON C. GRAHAM, manager of the research department of The Great Western Sugar Co., Denver, visited Boston, New York and other Eastern centers following his attendance at the meeting of the Chemical Engineers at Gorham, N. H.

WM. H. HUBBARD, mechanical superintendent of the Balbach Smelting and Refining Company, Newark, N. J., has resigned to take a similar position at the Northport Smelting and Refining Co., Northport, Wash.

M. R. HULL has accepted the position of designing engineer for the Nevada Consolidated Copper Co., at McGill, Nev. Mr. Hull recently returned from the Ural Mountains, Siberia, with orders to proceed with the design of a new copper smelter for the Sissert Mining Co. The mines and smelter have since been seized by the Bolshevik government, however, and the managing director, MR. NORMAN C. STINES, is lost and reported to be a prisoner in Germany. These facts, together with the impossibility of transferring funds, have necessitated the abandonment of the unfinished work.

MR. MILO W. KREJCI has resigned from the position of assistant superintendent of the Boston and Montana Reduction Works of the Anaconda Copper Mining Company, Great Falls, Montana, to enter consultation practice, and will be succeeded by J. O. Elton, formerly superintendent of the zinc refinery. Mr. Krejci retires after a service of nearly twenty years, during which time he had superintended nearly every department of the plant. As metallurgist his influence on the development of the 20-foot converter and other Great Falls contributions to the metallurgy of copper was very strong. Recently he has been largely interested in the electrolytic copper and zinc refineries, and has studied the possibilities of making brass in electric furnaces very exhaustively.

CHARLES R. KUZELL has resigned from the staff of the Anaconda Copper Mining Company to assume a position at the United Verde Smelter at Clarkdale, Ariz. MR. KUZELL was superintendent of reverberatory smelting at the Washoe Reduction Works.

MR. B. F. LAFOLETTE, who has had charge of the Engineering, Sales and Advertising Departments for the Clarage Fan Company, Kalamazoo, Mich., has resigned to get into Government Service, July 1. He will be located in either Philadelphia or Washington as an engineer with the Requirements Division of the U. S. Shipping Board.

PROF. S. K. LOY, Professor of Chemistry at the University of Wyoming, Laramie, Wyo., has accepted the position of chief chemist with the Midwest Refining Company, Casper, Wyoming.

MR. CHAS. H. MACDOWELL has presented his resignation as a member of the Committee on Fertilizers of the Chemical Alliance, stating that on account of his duties on the War Industries Board he found it impossible to attend the meetings. MR. DEWITT BROWN of Chicago was unanimously elected to succeed Mr. MacDowell.

MR. A. G. MCGREGOR has returned to Warren, Arizona, from a trip to South America, where he is supervising the construction of a new plant for the Cerro de Pasco Copper Corporation.

MR. ALEXANDER ORSCHEFSKY has been made supervisor of the analytical laboratory of the Chrome Plant of the Metal & Thermite Corporation, superseding MR. ABRAHAM L. KONWISER, who resigned.

MR. HERMAN F. SCHOLTZ, assistant chief engineer of the Newport Hydro Carbon Company, and the Newport Chemical Works, Inc., at Carrollville, Wis., has been assigned to active duty as Captain in the Engineer Officers Reserve.

## Obituary

MR. C. B. SPRAGUE, chief chemist for the United States Smelting, Refining and Mining Company, died at Salt Lake City, Utah, June 8, from injuries received three days earlier when a speeding automobile in which he was riding struck a fire plug. All the occupants of the machine except the driver also met their death. Mr. Sprague was born in Salt Lake City on Nov. 23, 1875, and attended the University of Utah. He had been employed by the United States Company since 1906, during which time he had paid particular attention to the action of smelter smoke on vegetation and live stock. He was widely known on account of his process of using volatile basic oxides to neutralize sulfuric acid anhydride in smelter gases before bag-housing. This process has been used in the Midvale and Mammoth plants of his own company, and the Murray and Perth Amboy plants of the A. S. & R. Co.

DR. WILLIAM B. PHILLIPS, geologist, died at his home in Houston, Tex., on June 7, aged 61 years. He was born in 1857 at Chapel Hill, N. C., and was educated at the University of North Carolina, where both his father and grandfather had been teachers. Upon his graduation, when he was 20 years old, he went to Saxony, where he studied at the Freiberg School of Mines. For a time after obtaining his degree, he was employed as chemist at the North Carolina Experiment Station. Later, from 1886 to 1888, he taught agricultural chemistry and mineralogy at the University of North Carolina, following in his father's steps. From 1888 to 1892 he practiced as a mining engineer at Birmingham, Ala. During this time he accepted a position in chemistry and metallurgy at the University of Alabama, which he held for two years, then becoming chemist for the Tennessee Coal, Iron and Ry. Co. At this period, he also served on the staff of the *Engineering and Mining Journal*. In 1901 he became director of the University of Texas mineral survey, remaining until 1905, when he again took up private work. In 1909 he was called to take charge of the newly created bureau of economic geology and technology at the university. He resigned this position in 1914 to take the presidency of the Colorado School of Mines, which office, however, he gave up a year later, preferring private practice. He was the author of about 300 scientific and technical articles. Dr. Phillips was a member of the American Institute of Mining Engineers. He was a Mason and a member of the Phi Beta Kappa and Phi Kappa Sigma fraternities.

## Current Market Reports

### Non-Ferrous Metal Market

**Tuesday, June 25.**—Prices have a tendency to rise except where the government has fixed set rates.

**Aluminum:**—The government price is 33c. a pound f.o.b. plant in 50-ton lots, 33.1c. down to 15-ton lots, and 33.2c. in lots down to 1 ton.

**Antimony:**—Good buying has prevailed and dealers are quoting firm in the range of 13% @ 13%.

**Chrome:**—Producers have established a schedule on the basis of \$1.30 per unit ore.

**Copper:**—Distribution of copper on the basis of 23½c. to consumers and 24.67½c. to dealers continues by the producers' committee.

**Lead:**—With the reaching of a price agreement on lead by the producers' committee last week, speculation is eliminated for the duration of the war. The New York basis will be 7.82½c. and East St. Louis, 7.75c.

**Manganese:**—Variable ton unit scale price, 40 per cent \$1.10, 50 per cent \$1.20. For full specifications see METALLURGICAL AND CHEMICAL ENGINEERING, page 629, June 15.

**Molybdenum:**—Quoted at \$1.25 per pound for 90% molybdenum sulphide.



**Spelter.**—Exceptionally strong conditions have ruled the market for prime Western spelter during the past few days and new high prices have been made. Spot New York 8.25 @ 8.37½c. and East St. Louis at 8.20 @ 8.30c.

**Tin.**—Much interest was manifested by the plan of the government to fix the price of tin. To do this the co-operation of the British, Dutch and Chinese governments will be essential and it is improbable that the latter two will agree; 81c. per lb. for August and September deliveries has been quoted, 90 to 95c. normal. Most of the shipments are coming in via the coast with high freight rates.

**Tungsten.**—The highest grade material containing no tin, no copper, low manganese and over 70% WO. has brought \$24.00 per ton unit. Impure material has sold as low as \$19.00.

|                                     |           |
|-------------------------------------|-----------|
| Bismuth .....                       | \$ 3.50   |
| Cadmium .....                       | 1.40-1.50 |
| Nickel .....                        | .40       |
| Silver .....                        | .994      |
| Platinum, oz. ....                  | 105.00    |
| Palladium, oz. ....                 | 135.00    |
| Cobalt .....                        | 2.50-3.50 |
| Magnesium .....                     | 1.75-2.00 |
| Quicksilver, California (75 lb.) .. | 125.00    |
| Mexican (75 lb.) ..                 | 118.00    |

### The Iron and Steel Market

By announcement of June 24 the War Industries Board has continued for another three months, or through September 30, the set prices for pig iron, unfinished steel and finished steel products. Lake Superior iron ore is advanced 45 cents per ton. Various arguments had been presented that there should be advances in one product or another, but the War Industries Board, undoubtedly in collaboration with the Federal Trade Commission, which has complete cost data from all makers, was quite indisposed to make any changes except in the downward direction, and was particularly desirous of avoiding any change that would disturb the present smooth working of things.

The exception made in the case of Lake Superior iron ore was due to the combination of facts that the ore must, beginning June 25, pay advanced rail freights equal to 30 cents per net ton, equal to 33.6 cents per gross ton, although as a matter of fact rates as revised are taken at the nearest ten cent multiple, and that the cost of mining has so advanced, since the expiring ore prices were originally made, November 23, 1916, that the ore producers are in no position to pay the freight advance. It is purely an incident, moreover, that the ore interests were called upon to pay the freight advance in the first place, this being due to the fact that the original freight advance order required that the ore freight advance be paid upon the first haul of the iron ore, while custom has it that Lake Superior iron ore prices are made at Lake Erie dock, and practically all the ore must pay the advance to get to lake water.

The ore advance plus the advanced freight rates on coke, limestone and other supplies, cause an increase in the cost of making a ton of pig iron, at the typical northern furnaces, of more than \$1.50. This, however, tends to offset the fact that the authorities at Washington have always considered the pig iron basis, \$33, a trifle too high, their original idea having been \$30.

### PITTSBURGH BASIS RESTORED

As noted above, the existing set maximum prices for unfinished and finished steel were continued. One change, however, is made. Bars, shapes and plates, at 2.90c., 3c. and 3.25c., respectively, are set purely on a Pittsburgh basis, the separate Chicago basing point being eliminated. When the original price announcement was made, September 24, 1917, the bar, shape and plate prices were announced as f.o.b. Pittsburgh or Chicago, greatly to the surprise of the trade. Only in times of exceptionally sharp competition in finished steel products, when the market was quite disorganized, have additional basing points been considered or recognized in actual transactions, and for a stable market, such as it is especially desired by all should obtain at this time, the single basing point is virtually a *sine qua non*.

That the great majority of iron and steel producers have been making large profits, and will continue to make large

profits, with the set prices continued, goes without saying. The argument that there are some small producers whose costs are exceptionally high has resulted in no action by the War Industries Board, either because the reports to the Federal Trade Commission did not disclose important cases of that description, or from the practical consideration that if a producer's costs are high it is usually because there is an excessive employment of labor or raw materials, the very elements in which there is a scarcity that is restricting to some extent the production of pig iron and steel. The practical thing if such a condition existed would be to release the labor and raw materials that are being wastefully employed, and use them efficiently elsewhere.

### DISTRIBUTION

The system of distribution of pig iron and steel products to the more essential commercial industries is proceeding quite smoothly. The "schedule of purposes entitled to preference treatment" was promulgated by the War Industries Board's resolutions of June 6, referred to in last report. A revised schedule was promised, but is not yet promulgated. The merchant furnaces and steel mills are finding no particular difficulty in interpreting the regulations, and any doubtful cases can readily be referred to Washington.

The regulations are proving not nearly as drastic as they have been painted, for the simple reason that the demand, or requirements, left out represents a relatively small tonnage, generally estimated at less than 10 per cent of the production. From this it becomes evident that if, after all priorities, allocations and preferences are taken care of there is any pig iron or steel left, it would not require a great deal to produce an actual surplus.

That the war requirements are going to be met fully in all directions is now evident, provided there is no serious curtailment in production from the rate of the past three months. Of all the war requirements the greatest doubt existed in the case of plates for shipbuilding, and yet with shipbuilding speeded up and looking forward to still greater activity, the Director General of Shipbuilding has testified before a congressional committee that he has no uneasiness as to the supply of steel for shipbuilding, his concern being as to accessories, first engines, second boilers and afterwards a variety of minor accessories. All the plans for the war activities contemplate the accumulation, if possible, of surpluses of steel as a measure of safety.

### PRODUCTION

Production of pig iron and steel ingots has been at a slightly greater rate than that of May, when there was a slight improvement, over April, in pig iron, but a slight loss in ingots. The weather on the whole has been a trifle more favorable. July and August are expected to witness considerable shrinkage, but every effort is being made in the industry to curtail the shrinkage that in past summers has been regarded as altogether unavoidable. Labor is scarce, but the scarcity has not interfered greatly with production, and some hopes are entertained that labor conditions may be improved by the regulation now undertaken by the Department of Labor, whereby employers are to avail themselves of the recently established governmental employment agencies and are expected to refrain from paying bonuses or "privatizing" in other ways upon the working forces of other employers.

### Chemical Market

**HEAVY CHEMICALS.**—The latter part of the period of the last two weeks has shown considerable lack of activity with a few transactions worthy of note while in matter of price there have developed advances in a few directions with a shading off in others. In most instances however the tendency has been upward.

**Bichromate of Soda.**—There has been a continued activity in this item on substantial demand. Actual sales of spot material have been made at 27½c. but up to 28c. was the last reported general trading level. Sizable quantities have been difficult to locate probably because stocks are in very strong hands who have chosen to sit back and await developments of the upward trend.

**Soda Ash:**—The market has been quiet but actual buyers are reported as having paid 2.90. The general market is asking 3c. to 3.05. Bags from dock were available in a small way at 2.20 but from warehouse, one car was reported as selling at 2.35, which is the generally quoted figure for important business.

**Sulphuric Acid:**—Quite in line with the general prophecies made at the time of our last report there has developed a shortage in this material accompanied by an appreciation in prices. The 66% brimstone is being offered in tank car lots at 37.50 with quotations from some directions of 40.00. In drums 40.00 and 42.00 are quoted with drums extra. The 60% is being offered in certain directions only for delivery in tank car quantities at 27.00 and there is very little to be obtained, some producers having already stopped quoting.

**Caustic Soda:**—Buyers have been showing very little interest and the result has been a decline in price asked on rolling material. The last reported on this type of business was 4c. with material from dock at 4.15 and from warehouse at 4.20 although these prices were considered a little low as the regular traders are quoting from 4.25 to 4.50 on standard brands.

**Yellow Prussiate of Soda:**—There has been a continued depreciation in price with material rolling to New York available at 61c. and 61½c. Spot prices quoted range from 62 to 64c. Sellers are showing more firmness in light of a renewed inquiry in the last few days.

**Glycerine:**—The first transaction for a lengthy period was made at 62c., covering about ten cars of dynamite material. Sales of the soap lye, loose, have been noted at 44c. and 46c.

**COAL TAR PRODUCTS:**—Offerings of most materials have been plentiful but the market has been quiet with a slight falling off in some instances from prices last quoted on a few items. The general tendency however is toward advance also in these materials.

**Formaldehyde:**—It is understood that restriction has been placed on this material by the government with a setting of a price of 16¼c. works and 16½c. New York. The latest reports disclose offerings of resale material at 17c. in one direction.

**Benzol:**—This market is fast approaching gasoline prices which brings this fuel again into serious consideration as a substitute. Large producers are willing to accept 23c. in tank car lots and from other directions material in drums is being quoted at 26 and 27c.

**Phenol:**—The developments have been interesting in spite of the report that the government has purchased 1,000,000 tons for picric acid manufacture. Export licenses for shipment of material to the Far East have been granted and some of the English phenol has been received in this country. In export drums the price was 47c. and for domestic drums 48c. is the general level.

**Toluol:**—Dye manufacturers are said to be receiving continual releases at the government price of 1.50 for tanks and 1.55 for drums. Resale material is now seldom heard of and then usually in single drum offers.

**Hydroquinone:**—One of the most favored makes is said to be purchasable at 2.65 through second hands but from 2.75 to 3.00 is the generally quoted range.

**Benzoate of Soda:**—There has been slight inquiry with a depreciation in price to the generally quoted level of from 3.15 to 3.25 for the toluol product. Manufacturers using the benzol process are quoting from 3.00 to 3.25, depending upon quantity.

**Benzoic Acid:**—The acid is showing a firm tone with quotations on the basis of from 3.45 to 3.70 for the acids from both the toluol and benzol processes.

**Metatoluenediamine:**—Very little is being offered so far as can be learned and it is reported that the leading producers are sold ahead. Last sales reported were on the basis of from 1.85 to 2.00.

**Aniline Oil:**—Manufacturers are not meeting the prices asked for resale material and are holding at 27 and 28c.

## General Chemicals

WHOLESALE PRICES IN NEW YORK MARKET, JUNE 26, 1918

|                                                      |         |               |        |
|------------------------------------------------------|---------|---------------|--------|
| Acetic anhydride.....                                | lb.     | 1.50          | 1.60   |
| Acetone, drums.....                                  | lb.     | Nominal       |        |
| Acetic acid, 28 per cent.....                        | lb.     | Nominal       |        |
| Acetic, 56 per cent.....                             | lb.     | Nominal       |        |
| Acetic, glacial, 99½ per cent., carboys.....         | lb.     | Nominal       |        |
| Boric, crystals.....                                 | lb.     | .13½          | .14    |
| Calcic, crystals.....                                | lb.     | .87           | .88    |
| Hydrochloric, C. P.....                              | lb.     | Nominal       |        |
| Hydrochloric, 20 deg.....                            | lb.     | .02           | .02½   |
| Hydrochloric, conc., 22 deg.....                     | lb.     | .02½          | .03    |
| Hydrofluoric, 20 per cent., in barrels.....          | lb.     | .18           | .19    |
| Lactic, 44 per cent.....                             | lb.     | .15           | .15½   |
| Lactic, 22 per cent.....                             | lb.     | .06           | .06½   |
| Molybdic, 85 per cent.....                           | lb.     | 3.85          |        |
| Nitric, 36 deg.....                                  | lb.     | Nominal       |        |
| Nitric, 42 deg.....                                  | lb.     | .09           | .10    |
| Oxalic, crystals.....                                | lb.     | .43           | .45    |
| Phosphoric, 47-50 per cent. paste.....               | lb.     | .08           | .10    |
| Phosphoric, red, 50 per cent.....                    | lb.     | .26           |        |
| Picric.....                                          | lb.     | Nominal       |        |
| Pyrogallol, resublimed.....                          | lb.     | 3.10          | 3.15   |
| Sulphuric, 60 deg.....                               | ton     | Nominal       |        |
| Sulphuric, 66 deg.....                               | ton     | 37.50         | 40.00  |
| Sulphuric, oleum (Fuming), tank cars.....            | ton     | 00.00         | 65.00  |
| Tannic, U. S. P., bulk.....                          | lb.     | 1.30          | 1.35   |
| Tartaric, crystals.....                              | lb.     | .87           | .88    |
| Tungstic, per 100 of W.....                          | lb.     | 1.70          | 1.75   |
| Alcohol, sugar cane, 188 proof.....                  | gal.    | 4.89          | 4.90   |
| Alcohol, wood, 95 per cent.....                      | gal.    | .90           | .91    |
| Alcohol, denatured, 180 proof.....                   | gal.    | .67           | .68    |
| Alum, ammoniac lump.....                             | lb.     | .04           | .04½   |
| Alum, chrome ammonium.....                           | lb.     | .17½          | .18    |
| Alum, chrome potassium.....                          | lb.     | .20           | .21    |
| Alum, chrome sodium.....                             | lb.     | .12½          | .13    |
| Alum, potassium.....                                 | lb.     | .18           | .19    |
| Aluminum sulphate, technical.....                    | lb.     | .02½          | .03    |
| Aluminum sulphate, iron free.....                    | lb.     | .03½          | .03½   |
| Ammonia aqua, 26 deg. carboys.....                   | lb.     | (Fixed Price) |        |
| Ammonia, anhydrous.....                              | lb.     | Nominal       |        |
| Ammonium carbonate.....                              | lb.     | .15           | .16    |
| Ammonium nitrate.....                                | lb.     | (Fixed Price) |        |
| Ammonium sulphate domestic.....                      | lb.     | .07½          | .08    |
| Amyl acetate.....                                    | gal.    | 5.00          | 5.25   |
| Arsenic, white.....                                  | lb.     | .09           | .16½   |
| Arsenic, red.....                                    | lb.     | .60           | .70    |
| Barium carbonate, 99 per cent.....                   | ton     | 80.00         | 90.00  |
| Barium carbonate, 97-98 per cent.....                | ton     | 65.00         | 67.00  |
| Barium chloride.....                                 | ton     | 65.00         | 85.00  |
| Barium sulphate (Blanc Fixe, Dry).....               | lb.     | .05           | .05½   |
| Barium nitrate.....                                  | lb.     | .10           | .11    |
| Barium peroxide, basic 70 per cent.....              | lb.     | .18           | .32    |
| Bleaching powder, 35 per cent. chlorine.....         | lb.     | .01           | .02    |
| Borax, crystals, racks.....                          | lb.     | .07½          | .08½   |
| Brimstone, crude.....                                | ton     | Nominal       |        |
| Bromine, technical.....                              | lb.     | .75           |        |
| Calcium, acetate, crude.....                         | lb.     | Nominal       |        |
| Calcium, carbide.....                                | lb.     | .14           | .16    |
| Calcium chloride, 70-75 per cent., fused, lump.....  | ton     | 27.50         | 30.00  |
| Calcium hypochlorite.....                            | lb.     | 1.60          | 1.70   |
| Calcium phosphate.....                               | lb.     | .34           | .35    |
| Calcium sulphate 98-99 per cent.....                 | lb.     | .09           | .09½   |
| Carbon bisulphide.....                               | lb.     | .08½          | .12    |
| Carbon tetrachloride, drums.....                     | lb.     | .15½          | .16    |
| Carbonyl chloride (phosgene).....                    | lb.     | 1.10          | 1.50   |
| Caustic potash, 88-92 per cent.....                  | lb.     | .79           | .82    |
| Caustic soda, 76 per cent.....                       | 100 lb. | 4.00          | 4.25   |
| Chlorine, liquid.....                                | lb.     | (Fixed Price) |        |
| Cobalt oxide.....                                    | lb.     | 1.60          | 1.65   |
| Copperas.....                                        | lb.     | .01½          | .01½   |
| Copper carbonate.....                                | lb.     | .30           | .40    |
| Copper cyanide.....                                  | lb.     | .46           | .78    |
| Copper sulphate, 99 per cent., large crystals.....   | lb.     | .08½          | .09    |
| Cream of tartar, crystals.....                       | lb.     | .77           | .80    |
| Epom salt, bags, U.S.P.....                          | lb.     | .03½          | .03½   |
| Formaldehyde, 40 per cent.....                       | lb.     | .16½          | .17½   |
| Glauber's salt.....                                  | 100 lb. | 1.70          | 1.80   |
| Glycerine, bulk, C. P.....                           | lb.     | .62           | .65    |
| Iodine, resublimed.....                              | lb.     | 4.25          | 4.30   |
| Iron oxide.....                                      | lb.     | .13           | .15    |
| Lead, acetate, white crystals.....                   | lb.     | .17           | .18    |
| Lead, arsenate (Pasta).....                          | lb.     | .15           | .18    |
| Lead nitrate.....                                    | lb.     | Nominal       |        |
| Litharge, American.....                              | lb.     | 1.50          | 1.03   |
| Lithium carbonate.....                               | lb.     | .70           | 2.00   |
| Manganese dioxide, U. S. P.....                      | lb.     | .70           | .75    |
| Magnesium carbonate, technical.....                  | lb.     | .12           | .13    |
| Nickel salt, single.....                             | lb.     | .14           | .15    |
| Nickel salt, double.....                             | lb.     | .12           | .14    |
| Phosgene, see Carbonyl chloride.....                 |         |               |        |
| Phosphorus, red.....                                 | lb.     | 1.30          | 1.50   |
| Phosphorus, yellow.....                              | lb.     | .60           | 1.25   |
| Potassium bichromate.....                            | lb.     | .46           | .50    |
| Potassium bromide.....                               | lb.     | 1.35          | 1.50   |
| Potassium carbonate calcined, 85-90 per cent.....    | lb.     | .40           | .50    |
| Potassium chlorate, crystals.....                    | lb.     | .30           | .40    |
| Potassium cyanide, 98-99 per cent.....               | lb.     | Nominal       |        |
| Potassium iodide.....                                | lb.     | 3.75          | 3.80   |
| Potassium muriate 80-85 p. c. basis of 80 p. c.....  | ton     | 300.00        | 350.00 |
| Potassium nitrate.....                               | lb.     | .27           | .30    |
| Potassium permanganate (U. S. F.).....               | lb.     | 2.50          | 3.00   |
| Potassium prussiate, red.....                        | lb.     | 2.80          | 2.90   |
| Potassium prussiate, yellow.....                     | lb.     | 1.10          | 1.20   |
| Potassium sulphate, 90-95 p. c. basis 90 p. c.....   | ton     | Nominal       |        |
| Rochelle salts.....                                  | lb.     | .44½          | .45    |
| Salammoniac, gray gran.....                          | lb.     | .22           | .23    |
| Salammoniac, white gran.....                         | lb.     | .20           | .21    |
| Salt soda, 100 lb.....                               | 100 lb. | 1.40          | 1.50   |
| Salt cake.....                                       | ton     | 22.00         | 25.00  |
| Silver cyanide, based on market price of silver..... | oz.     | .62½          | .63    |
| Silver nitrate.....                                  | oz.     | .62½          | .63    |
| Soda ash, 58 per cent., light, flat (bags).....      | 100 lb. | 2.70          | 2.80   |
| Soda ash, 58 per cent., dense, flat.....             | 100 lb. | 4.00          | 4.10   |
| Sodium acetate.....                                  | lb.     | .27           | .28    |
| Sodium bicarbonate, domestic.....                    | lb.     | .02½          | .03    |
| Sodium bicarbonate, English.....                     | lb.     | .28           | .28½   |
| Sodium bichromate.....                               | lb.     |               |        |

|                                        |         |         |   |      |
|----------------------------------------|---------|---------|---|------|
| Sodium bisulphite, powd.               | lb.     | .12     | — | .13  |
| Sodium chlorate                        | lb.     | .24     | — | .25  |
| Sodium cyanide                         | lb.     | .39     | — | .40  |
| Sodium fluoride, commercial            | lb.     | .18     | — | .19  |
| Sodium hyposulphite                    | lb.     | 2.40    | — | 2.50 |
| Sodium molybdate, per lb. of Mo.       | lb.     | 2.50    | — | 2.50 |
| Sodium nitrate, 95 per cent            | 100 lb. | Nominal | — |      |
| Sodium nitrite                         | lb.     | .28     | — | .30  |
| Sodium selenate                        | lb.     | .35     | — | .35  |
| Sodium phosphate                       | lb.     | .04     | — | .05  |
| Sodium prussiate, yellow               | lb.     | .62     | — | .65  |
| Sodium silicate, liquid (60 deg.)      | lb.     | Nominal | — |      |
| Sodium sulphate, 30 per cent, crystals | lb.     | Nominal | — |      |
| Sodium sulphide, 60 per cent, fused    | 100 lb. | Nominal | — |      |
| Sodium sulphite                        | lb.     | Nominal | — |      |
| Strontium nitrate                      | lb.     | .25     | — | .35  |
| Sulphur chlorides, drums               | lb.     | .06     | — | .04  |
| Sulphur dioxide, liquid, in cylinders  | lb.     | .15     | — | .40  |
| Sulphur, flowers, sublimed             | 100 lb. | 4.05    | — | 4.60 |
| Sulphur, roll                          | 100 lb. | 3.70    | — | 3.85 |
| Sulphur, crude                         | ton     | Nominal | — |      |
| Tin bichloride, 50 deg                 | lb.     | .274    | — | .28  |
| Tin oxide                              | lb.     | 1.00    | — | 1.25 |
| Zinc carbonate                         | lb.     | .28     | — | .30  |
| Zinc chloride                          | lb.     | .15     | — | .18  |
| Zinc cyanide                           | lb.     | Nominal | — |      |
| Zinc dust, 350 mesh                    | lb.     | .14     | — | .16  |
| Zinc oxide, American process XX        | lb.     | .13     | — | .14  |
| Zinc sulphate                          | lb.     | .044    | — | .05  |

## Coal Tar Products (Crude)

|                                        |                    |      |   |       |
|----------------------------------------|--------------------|------|---|-------|
| Benzol, pure, water white              | gal.               | .23  | — | .26   |
| Benzol, 90 per cent                    | gal.               | .25  | — | .25   |
| Toluol, in tank cars                   | gal. (Fixed Price) | 1.50 | — |       |
| Toluol, for non-military use, in drums | gal. (Fixed Price) | 1.55 | — |       |
| Xylol, pure, water white               | gal.               | .45  | — | .55   |
| Solvent naphtha, water white           | gal.               | .17  | — | .22   |
| Solvent naphtha, crude, heavy          | lb.                | .13  | — | .16   |
| Cresosote oil, 25 per cent             | gal.               | .40  | — | .55   |
| Dip oil, 20 per cent                   | gal.               | .30  | — | .32   |
| Pitch, various grades                  | ton                | 8.00 | — | 20.00 |
| Carbolic acid, crude, 95-97 per cent   | lb.                | 1.05 | — | 1.10  |
| Carbolic acid, crude, 50 per cent      | lb.                | .60  | — | .65   |
| Carbolic acid, crude, 25 per cent      | lb.                | .35  | — | .38   |
| Cresol, U. S. P.                       | lb.                | .18  | — | .20   |

## Intermediates, Etc.

|                                |     |       |   |       |
|--------------------------------|-----|-------|---|-------|
| Alpha naphthol, crude          | lb. | 1.00  | — | 1.10  |
| Alpha naphthol, distilled      | lb. | 1.60  | — | 1.70  |
| Alpha naphthylamine            | lb. | .60   | — | .65   |
| Aniline oil, drums extra       | lb. | .25   | — | .36   |
| Aniline salts                  | lb. | .34   | — | .36   |
| Anthracene, 60 per cent        | lb. | .50   | — | .65   |
| Benzaldehyde (f.f.c.)          | lb. | 3.65  | — | 2.00  |
| Benzenide, base                | lb. | 1.75  | — | 2.60  |
| Benzenide, sulphate            | lb. | 1.40  | — | 1.50  |
| Benzoic acid U. S. P.          | lb. | 3.45  | — | 3.70  |
| Benzonate of Soda, U. S. P.    | lb. | 3.00  | — | 3.25  |
| Benzyl chloride                | lb. | 2.30  | — | 2.50  |
| Beta naphthol benzoate         | lb. | 10.00 | — | 12.00 |
| Beta naphthol, sublimed        | lb. | .85   | — | .90   |
| Beta naphthylamine, sublimed   | lb. | 2.65  | — | 3.10  |
| Dichlor benzol                 | lb. | .12   | — | .20   |
| Diethylaniline                 | lb. | 5.00  | — | 5.00  |
| Dinitro benzol                 | lb. | .35   | — | .40   |
| Dinitrochlorobenzol            | lb. | .40   | — | .42   |
| Dinitrophenathaline            | lb. | .60   | — | .70   |
| Dinitrotolul                   | lb. | .60   | — | .65   |
| Dinitrophenol                  | lb. | .46   | — | .50   |
| Diethylaniline                 | lb. | .75   | — | .80   |
| Diphenylamine                  | lb. | 1.00  | — | 1.10  |
| H-acid                         | lb. | 2.30  | — | 3.00  |
| Metaphenylenediamine           | lb. | 1.75  | — | 2.00  |
| Monochlorbenzol                | lb. | .17   | — | .20   |
| Naphthalene, flake             | lb. | .094  | — | .104  |
| Naphthalene, balls             | lb. | .104  | — | .104  |
| Naphthalene acid, crude        | lb. | 1.20  | — | 1.30  |
| Naphthylamine-di-sulphate acid | lb. | 1.00  | — | 1.10  |
| Nitro naphthaline              | lb. | .45   | — | .50   |
| Nitro toluol                   | lb. | .60   | — | .65   |
| Ortho-amidophenol              | lb. | .15   | — | .18   |
| Ortho-dichlor-benzol           | lb. | .15   | — | .18   |
| Ortho-toluidine                | lb. | 1.00  | — | 1.25  |
| Ortho-nitro-tolul              | lb. | .75   | — | .80   |
| Para-amidophenol               | lb. | 4.00  | — | 4.25  |
| Para-amido-phenol, H. Ch       | lb. | 4.00  | — | 5.00  |
| Para-dichlor-benzol            | lb. | .12   | — | .15   |
| Paranitraniline                | lb. | 1.60  | — | 1.70  |
| Paranitro-tolul                | lb. | 1.50  | — | 1.60  |
| Paraphenylenediamine (base)    | lb. | 3.50  | — | 4.00  |
| Para toluidine                 | lb. | 2.50  | — | 2.25  |
| Phthalic acid anhydride        | lb. | 3.00  | — | 4.48  |
| Phenol, U. S. P.               | lb. | .47   | — | .48   |
| Resorcin, technical            | lb. | 5.00  | — | 6.00  |
| Resorcin, pure                 | lb. | 8.00  | — | 9.00  |
| Salicylic acid                 | lb. | .90   | — | .90   |
| Salicylic acid                 | lb. | 1.90  | — | 2.00  |
| Sulphanilic acid, crude        | lb. | .30   | — | .32   |
| Tolidin                        | lb. | 2.50  | — | .50   |
| Toluidine-mixture              | lb. | .85   | — | .90   |

## Petroleum Oils

Crude (at the Wells)

|                        |      |      |   |  |
|------------------------|------|------|---|--|
| Pennsylvania           | bbl. | 4.00 | — |  |
| Corning, Ohio          | bbl. | 2.85 | — |  |
| Summit, Ky.            | bbl. | 2.60 | — |  |
| Wagoner, Ohio          | bbl. | 2.68 | — |  |
| Indiana                | bbl. | 2.28 | — |  |
| Illinois               | bbl. | 2.22 | — |  |
| Oklahoma and Kansas    | bbl. | 2.25 | — |  |
| Caddo, La., light      | bbl. | 2.25 | — |  |
| Corsicana, Tex., light | bbl. | 2.25 | — |  |
| California             | bbl. | 1.25 | — |  |
| Gulf Coast             | bbl. | 1.35 | — |  |

| Fuel Oil       |      |      |   |      |
|----------------|------|------|---|------|
| New York       | gal. | .11  | — | .11  |
| Pittsburgh     | gal. | .073 | — | .10  |
| Oklahoma-Kans. | bbl. | 1.56 | — | 2.75 |
| Texas          | bbl. | 1.85 | — | 2.35 |
| Los Angeles    | bbl. | 1.60 | — |      |
| San Francisco  | bbl. | 1.60 | — |      |

## Gasoline (Wholesale)

|               |      |      |   |  |
|---------------|------|------|---|--|
| New York      | gal. | .24  | — |  |
| Boston        | gal. | .25  | — |  |
| Pittsburgh    | gal. | .28  | — |  |
| Chicago       | gal. | .224 | — |  |
| Oklahoma      | gal. | .23  | — |  |
| San Francisco | gal. | .20  | — |  |

## Lubricants

|                                              |      |     |   |     |
|----------------------------------------------|------|-----|---|-----|
| Black, reduced, 29 gravity, 25-30 cold test. | gal. | .22 | — | .24 |
| Cylinder, light                              | gal. | .36 | — | .38 |
| Cylinder, dark                               | gal. | .37 | — | .38 |
| Paraffine, high viscosity                    | gal. | .40 | — | .41 |
| Paraffine, 903 sp. gr.                       | gal. | .36 | — | .38 |
| Paraffine, 885 sp. gr.                       | gal. | .26 | — | .28 |

## Flotation Oils

(Prices at New York unless otherwise stated)

|                                                                     |      |     |   |     |
|---------------------------------------------------------------------|------|-----|---|-----|
| Pine oil, crude, f. o. b. Florida                                   | gal. | .44 | — | .58 |
| Pine oil, steam-distilled, sp. gr. 0.925-0.940                      | gal. | .49 | — | .50 |
| Pine oil, destructively distilled                                   | gal. | .49 | — | .50 |
| Pine-tar oil, sp. gr. 1.025-1.035                                   | gal. | .35 | — |     |
| Pine-tar oil, double refined, sp. gr. 0.965-0.990                   | gal. | .40 | — |     |
| Pine-tar oil, ref., light, sp. gr. 0.970, tank cars, f. o. b. works | gal. | .37 | — |     |
| Pine-tar oil, ref., heavy, sp. gr. 1.025, tank cars, f. o. b. works | gal. | .28 | — |     |
| Pine-tar oil, ref., thin, sp. gr. 1.060-1.080                       | gal. | .32 | — |     |
| Turpentine, crude, sp. gr. 0.870-0.900                              | gal. | .40 | — |     |
| Hardwood oil, f. o. b. Michigan, sp. gr. 0.960-0.990                | gal. | .23 | — |     |
| Hardwood oil, f. o. b. Michigan, sp. gr. 1.06-1.08                  | gal. | .23 | — |     |
| Wood creosote, ref. f. o. b. Florida                                | gal. | .31 | — |     |

## Vegetable and Other Oils

|                          |      |      |   |       |
|--------------------------|------|------|---|-------|
| China wood oil           | lb.  | .26  | — | .27   |
| Cottonseed oil, crude    | lb.  | .21  | — | .22   |
| Linseed oil, raw, cars   | gal. | 1.60 | — |       |
| Peasut oil, crude        | gal. | 1.36 | — | 1.364 |
| Rosin oil, first run     | gal. | .41  | — | .43   |
| Rosin oil, fourth run    | gal. | .63  | — |       |
| Soya bean oil, Manchuria | lb.  | .18  | — |       |
| Turpentine, spirits      | gal. | .75  | — |       |

## Miscellaneous Materials

|                                     |         |         |   |         |
|-------------------------------------|---------|---------|---|---------|
| Barytes, floated, white, foreign    | ton     | 38.00   | — | 42.00   |
| Barytes, floated, white, domestic   | ton     | 32.00   | — | 36.00   |
| Beeswax, white, pure                | lb.     | .62     | — | .64     |
| Casien                              | lb.     | .15     | — | .20     |
| Chalk, light, precipitated, English | lb.     | .15     | — | Nominal |
| China clay, imported, lump          | ton     | 17.50   | — | 36.00   |
| China clay, domestic, lump          | ton     | 12.50   | — | 20.00   |
| Feldspar                            | ton     | 8.00    | — | 12.00   |
| Fluorspar, gravel, f. o. b. mines   | ton     | 30.00   | — |         |
| Fuller's earth, powdered            | 100 lb. | 1.00    | — | 1.50    |
| Graphite, flake                     | lb.     | .15     | — | .18     |
| Ozokerite, crude                    | lb.     | Nominal | — |         |
| Ozokerite, American, refined, white | lb.     | Nominal | — |         |
| Red lead, dry, carloads             | lb.     | .10     | — | .114    |
| Rosin, 280 lb                       | bbl.    | 10.90   | — |         |
| Saponstone                          | ton     | 1.00    | — | 12.50   |
| Talc, American, white               | ton     | 15.00   | — | 22.00   |
| White lead, dry                     | lb.     | .094    | — | .104    |

## Refractories, Etc.

(F. O. B. Works)

|                                     |          |        |   |        |
|-------------------------------------|----------|--------|---|--------|
| Chrome brick                        | net ton  | 175.00 | — |        |
| Chrome cement                       | net ton  | 75.00  | — |        |
| Clay brick, light quality fireclay  | per 1000 | 50.00  | — | 55.00  |
| Clay brick, second quality fireclay | per 1000 | 35.00  | — | 40.00  |
| Magnesite, raw                      | ton      | 30.00  | — | 35.00  |
| Magnesite, calcined, powdered       | ton      | 50.00  | — | 65.00  |
| Magnesite, dead burned              | net ton  | 50.00  | — | 60.00  |
| Magnesia brick, 94x4x2 1/2          | net ton  | 110.00 | — | 125.00 |
| Silica brick                        | per 1000 | 50.00  | — | 60.00  |

## Ferroalloys

|                                                                               |      |        |   |        |
|-------------------------------------------------------------------------------|------|--------|---|--------|
| Ferrocobaltititanium, 15-18 per cent, carloads, f. o. b. Niagara Falls, N. Y. | ton  | —      | — |        |
| Ferroceroium                                                                  | lb.  | 15.00  | — | 20.00  |
| Ferrocromium, per lb. of Cr                                                   | ton  | 250.00 | — |        |
| Ferromanganese, domestic, 70 per cent, basis                                  | ton  | 325.00 | — |        |
| Ferromanganese, English                                                       | ton  | 5.00   | — |        |
| Ferromolybdenum, per lb. of Mo                                                | ton  | 180.00 | — | 190.00 |
| Ferrosilicon, 75 per cent, f. o. b. N. Y.                                     | ton  | 160.00 | — | 170.00 |
| Ferrosilicon, 50 per cent, carloads, del., Pittsburgh                         | ton  | 2.35   | — | 2.40   |
| Ferrosilicon, 50 per cent, contract                                           | ton  | 7.50   | — |        |
| Ferrotungsten, 75-85 per cent, f. o. b. Pittsburgh                            | lb.  | —      | — |        |
| Ferrovandium, f. o. b. works, per lb. of U.                                   | unit | —      | — |        |
| Ferrovandium, f. o. b. works                                                  | lb.  | —      | — |        |

## Ores and Semi-finished Products

|                                                          |      |       |   | Nominal |
|----------------------------------------------------------|------|-------|---|---------|
| Antimony ore, per unit                                   | ton  | 1.50  | — | 1.55    |
| Chrome ore, 45 per cent minimum, f. o. b. Cal., per unit | ton  | 1.20  | — |         |
| Chrome ore, 45 per cent and over, New York, per unit     | ton  | 80.00 | — | 100.00  |
| Chromite ore, 46 per cent and over, per unit             | ton  | 1.25  | — |         |
| Manganese ore, chemical                                  | lb.  | 24.00 | — |         |
| Molybdenite, per lb. of MoS <sub>2</sub>                 | ton  | 3.25  | — | 3.60    |
| Tungsten, Scheelite, per unit of WO <sub>3</sub>         | ton  | 10.50 | — |         |
| Tungsten, Wolframite, per unit of WO <sub>3</sub>        | unit | .28   | — | .30     |
| Uranium oxide, 96%                                       | lb.  | —     | — |         |
| Vanadium pentoxide, 99%                                  | lb.  | —     | — |         |
| Pyrites, foreign                                         | unit | —     | — |         |
| Pyrites, domestic                                        | unit | —     | — |         |



# INDUSTRIAL NEWS

## Plant Construction—Catalogs—New Publications

### Construction and Operation

#### Alabama

**ASHLAND**—The Empire Graphite Co. will rebuild its plant recently destroyed by fire with a loss of \$50,000.

**BIRMINGHAM**—The Ingalls Iron Works, Avenue D and Seventh St., will build a steel frame addition to its plant. Estimated cost, \$9,500.

#### Arkansas

**FORT SMITH**—The Arkansas Mining & Mercantile Co. will build a 200-ton concentration plant and its zinc and lead mine located between Boone and Marion Counties. Estimated cost, \$60,000. The company is in the market for drills, sludge and slime tables, engines, boilers, compressors, ore crushers, track, cars, belts and mill hardware. F. A. Handien, president and manager.

**ROGERS**—The Lenk Pat. Mining Co., Joplin, Mo., will build a concentration and stamp mill here and is in the market for crushers, rollers, sludge and slime tables, engines, boilers, etc. Estimated cost, \$100,000. P. Cleburn, Joplin, 530 Main St., Joplin, Mo., superintendent.

**ZINCO**—The Consolidated Zinc Mines Co., Dallas, Tex., will build a 400-ton concentration plant here. The company is in the market for sludge and slime tables, ore cars, scales, etc. Estimated cost, \$70,000. N. W. Palmer, Muskogee, Okla., superintendent.

#### Colorado

**LEADVILLE**—The Royal Tiger Mining & Milling Co. will build a 300-ton milling plant on its property in Swan Valley, north of Breckenridge.

#### Connecticut

**BRIDGEPORT**—Until July 11th, by Sewer and Paying Commission, building sewage disposal plant on Bostwick Ave.

**NEW HAVEN**—The United States War Department, Washington, D. C., will build a plant for the production of tolol from gas, to be located near the works of the New Haven Gas Co., on East Chapel St. Estimated cost, \$110,000. H. Koppers, Union Arcade, Pittsburgh, Pa., has charge of the work.

#### Illinois

**EPORIA**—The Peoria Tractor Co., 1100 West Washington St., has purchased a site on East Washington St. and will build a factory for the manufacture of machines.

#### Indiana

**WHITING**—The city plans to build a water filtration plant of 4,000,000 gal. daily capacity. Estimated cost, \$130,000. S. A. Greely, 64 West Randolph, Chicago, Ill., engineer.

#### Iowa

**CEJAR RAPIDS**—The La Plant Choate Steel Co., c/o E. W. La Plant, 1804 Bever Ave., has awarded the contract for the construction of a brick and mill construction factory, to Looms Bros. Perpetual Building.

**OTTUMWA JUNCTION**—The Chicago, Milwaukee & St. Paul Ry. Co. F. Loweth, chief engineer, Railway Exchange Building, Chicago, Ill., will build pumping station and filter plant of 70,000 gal. capacity, including pipe line and tank, which is a part of the new terminal facilities to cost, \$50,000.

#### Kansas

**BADGER**—The Badger Mining & Development Co., 103 Mines Bank Building Joplin, Mo., will build a 150-ton concentration plant on their 210 acre lease here and are in the market for sludge and slime tables, ore crushers, etc. Estimated cost, \$60,000. T. E. Forester, superintendent.

**BAXTER SPRINGS**—The Big Lead Mining Co., Muskogee, Okla., will build a

concentration plant here. Estimated cost, \$75,000. J. E. Hoshal, superintendent.

**BAXTER SPRINGS**—The Cortez Mining Co., Jefferson City, Mo., will build a 250-ton concentration mill and a 125-H. P. power plant requiring sludge and slime tables, motors and crushers. Estimated cost, \$68,000.

**BAXTER SPRINGS**—The Quaker Valley Mining Co. will build a concentration plant requiring crushers, engine, oilers and sludge tables. Estimated cost, \$50,000. W. W. Wakeman, superintendent.

**NEWTON**—The city plans to build sewage disposal plant consisting of pump house and pumps, imhoff tank, sprinkling filter, secondary settling tank and sludge filter, with connection sewers, manholes, etc. Black & Veatch, 502 Interstate Building, Kansas City, Mo., engineers.

#### Kentucky

**LEXINGTON**—The Lexington Roller Mills Co., 133-135 Broadway, has awarded the contract for the construction of a brick addition to its corn and flour mill, to Combs Lumber Co., 439 East Main St. Estimated cost, \$10,000.

**LOUISVILLE**—The Magic Keller Soap Co., 2745 Stokers St., has awarded the contract for the construction of a 4-story brick factory, to the National Concrete Construction Co., Board of Trade Building. Estimated cost, \$50,000.

#### Maryland

**FORT MCHENRY**—The Cantonment Division, War Department, Washington, D. C., will build a chemical laboratory at the general hospital here. About \$152,000, cost plus percentage.

**INDIAN HEAD**—The Bureau of Yards and Docks, Navy Department, Washington, D. C., will remodel its chemical laboratory here. Estimated cost, \$20,000.

#### Michigan

**DETROIT**—The J. E. Bolles Iron & Wire Works, Milwaukee Ave., between Hastings and Crystal Sts., has awarded the contract for the construction of a one-story, brick addition to its factory to Walbridge-Aldinger Co., 2356 Penobscot Building.

**GRAND RAPIDS**—The Rudy Furnace Co. has awarded the contract for the construction of another plant here to Byers Construction Co., Kalamazoo. Estimated cost, \$50,000.

#### Missouri

**JOPLIN**—The Kirkwood Mining Co., Room 12, Cunningham Building, will build a 150-ton concentration plant, requiring sludge tables, motors and crushers. Estimated cost \$40,000. S. A. Smith, general manager.

**JOPLIN**—The Klein & Stern Investment Co., Frisco Building, will build a 150-ton concentration plant requiring sludge and slime tables, crushers, belts, engines, etc. Estimated cost, \$25,000.

**JOPLIN**—The Miami Yellville Mining Co., West Seventh St., will remodel its concentration plant and install new machinery. Estimated cost, \$25,000. J. Taylor, c/o Liberty Theater, superintendent.

**JOPLIN**—The Muskogee Lead & Zinc Co. will build a 300-ton concentration mill requiring sludge tables, conveyors, air compressors. Estimated cost, \$58,000. E. C. Beatty, Springfield, manager.

**JOPLIN**—The New Carolyn Metal Co. has purchased the Nescho Granby Metal Co., and will build a new 300-ton mill and increase the capacity of the present 150-ton mill to 300-ton. The company is in the market for sludge tables, slime tables, crushers, air compressors, engines and boilers. Estimated cost, \$100,000. Nels Darling, Oklahoma City, Okla., superintendent.

**JOPLIN**—Paeffle & Keller, West Fourth St., will build 150-ton concentration plant at its mine. Estimated cost, \$25,000. W. Paeffle, Fourth and North Pearl Sts., superintendent.

**JOPLIN**—Piachard & Clear Mining Co., Cunningham Building, will remodel its concentration plant at its mine and also install new machinery. Estimated cost, \$26,000. Fletcher Clear, Joplin, superintendent.

**KANSAS CITY**—The Jensen-Salsberry Laboratories, 1320 Main St., will build a 3-story, 28 x 128 ft., reinforced concrete and brick laboratory. E. O. Brostrom, 212 Reliance Building, architect.

#### Nebraska

**LINCOLN**—The State Board of Control, J. S. Dales, secretary, will build a 3-story, 18 x 102 ft. laboratory building at Forty-second St. and Dewey Ave. Estimated cost, \$120,000. John Latenser & Sons, 626 Bee Building, architects.

#### New Jersey

**CAMDEN**—The Warren & Webster Co., Point and Pearl Sts., will build a 2-story, 43 x 71 ft., reinforced concrete, brick and steel factory, for the manufacture of heating systems and venting specialties, on north side of Pearl St., between Delaware Ave. and Point St., Ballinger & Perrot, Seventeenth and Arch Sts., Philadelphia, Pa., architects.

**NEWARK**—The Brady Brass Co., Fourteenth St., has awarded the contract for the construction of a 4-story, reinforced concrete and brick factory building, to J. Mitchell, Montgomery St. Estimated cost, \$25,000.

**IRVINGTON**—The Day-Elder Motors Co., 161 Ogden St., Newark, has awarded the contract for the construction of a brick and mill factory, on Central Ave., to H. er Construction Co., 161 Grove St., Newark.

**NEWARK**—The Mennen Gerhardt, Chemical Co., 40 Spring St., has awarded the contract for the construction of a brick addition to its plant on Central Ave., to H. M. Boremba & Co., Orange Ave. Estimated cost, \$45,000. Noted June 15.

**TRENTON**—John E. Thorp's Sons Co., Lewis St., will build a foundry and iron plant along the Delaware River, to J. E. Thorp, 1100, 000. J. Osborne Hunt, 114 North Montgomery St., architect.

#### New York

**BROOKLYN**—The Gotham Can Co., 69 Eagle St., has awarded the contract for the construction of a 3-story, 60 x 100 ft. factory, to W. R. McGarry Co., 306 Freeman St. Estimated cost, \$45,000.

**BUFFALO**—The Donner Steel Co., 475 Abbott Road, will build a reinforced concrete, brick and steel coke oven plant containing 180 ovens. Estimated cost, \$3,000,000. H. Koppers Co., Pittsburgh, Pa., engineers.

**BUFFALO**—The National Aniline & Chemical Co., Abbott Road, will build a 6-story, 150 x 250 ft., reinforced concrete, brick and steel factory addition. Estimated cost, \$300,000. H. McKaig Co., c/o owners, engineers.

**BUFFALO**—The Strong Steel Co., 33 Norris St., will build a 1-story, 80 x 300 ft., concrete, brick and steel foundry and machine shop. Estimated cost, \$75,000.

**LONG ISLAND CITY**—The Meurer Steel Barred Co., 575 Flushing Ave., has awarded the contract for the construction of a 1- and 2-story, 200 x 255 ft. factory to Peter Guthy, 926 Broadway, Brooklyn. Estimated cost, \$75,000.

**LONG ISLAND CITY**—The Rachel Asbestos Co., 609 West Twenty-second St., New York City, will build a 2-story, 90 x 115 ft., brick factory on Harris Ave. and Hancock St. Estimated cost, \$60,000. E. A. Richardson, 100 Amity St., architect.

**NIAGARA FALLS**—The Hydraulic Power Co., Hydraulic Canal, has awarded the contract for the construction of the substructure for a 3-story, 100 x 300 ft. hydroelectric plant at Canal Basin, to Dock Construction Co., 95 River St., Hoboken, N. J. Estimated cost, \$1,000,000.

**NIAGARA FALLS**—The United States Light & Heat Co., manufacturer of heating specialties, 3215 Highland Ave., will build a 1-story, 150x300 ft., reinforced concrete, brick and steel factory. Estimated cost, \$75,000. Mills, Rhines, Bellmire & Nordoff, Old Building, Toledo, O., architects.

**RED HOUSE**—A. B. Smith Co., White Building, Buffalo, will build a 2-story, 100 x 250 ft., brick chemical plant here. Estimated cost, \$35,000.

**ROCHESTER**—The Bridgeford Tool & Machine Co., Winton Ave., will build a 3-story, 60 x 200 ft. machine shop. Estimated cost, \$50,000. R. S. Byers, Chamber of Commerce Building, architect.

**ROCHESTER**—The Monroe Iron, Metal & Copperage Co., 510 State St., has awarded the contract for the construction of a 2-story, 50 x 100 ft. plant, to William Kenny, 86 Frost Ave. Estimated cost \$23,000.

**ROCHESTER**—The Vollensack Optical Co., 1415 Clinton Ave., N., will build a 2-story, 150 x 200 ft., reinforced concrete,

brick and steel optical plant. Estimated cost, \$75,000.

**SYRACUSE**—The Crucible Steel Co., 104 Madison St., has awarded the contract for the construction of a 1-story, 90 x 125 ft., concrete, brick and steel machine shop, to J. D. Taylor & Co., 115 South Salina St., Syracuse, N. Y. Estimated cost, \$40,000.

**UTICA**—The United States War Department, Washington, D. C., will build a plant on the east side of Snipe St. near the plant of the U. S. Gas & Electric Co., for the production of toluiol from gas. Estimated cost, \$65,000.

## Ohio

**CARTHAGE**—The Pollak Steel Co., Seventy-first St., Cincinnati, will build a 1-story press shop as an addition to its plant here. Estimated cost, \$8,000.

**CINCINNATI**—The Peerless Foundry Co., Eleventh and High Sts., has awarded the contract for the construction of a 1-story, 120 x 200 ft. and 60 x 120 ft. grey iron foundry, fire-proof construction, on Washington place, to J. M. Marcus Building Co., 2023 Reading Road. Estimated cost, \$75,000. Noted May 15.

**CLEVELAND**—The Cleveland Smelting & Refining Co., 357 Leader-News Building, has awarded the contract for smelting old and new metals. Estimated cost, \$200,000. E. A. Stotter, superintendent.

**CLEVELAND**—The Electrical Steel & Forge Co., Grant Ave. and Belt Line Railway, has awarded the contract for a 2-story, 100 x 200 ft. concrete, brick and steel rolling mill and warehouse. Estimated cost, \$100,000.

**ELIZABETHTOWN**—The Nitrate Division, Bureau of Ordnance, War Department, Washington, D. C., has awarded the contract for the construction of a plant for the manufacture of nitrate, to the Air Nitrate Corporation, 360 Madison Ave., New York City. Cost will run into millions.

**FINDLAY**—The Grant Motor Car Corporation, Coit and Kirley Aves., Cleveland, has awarded the contract for the construction of six factory buildings, brick and steel, to W. J. Thompson & Son Co., 6110 Euclid Ave., Cleveland. Estimated cost, \$100,000.

**FINDLAY**—The Giant Tire & Rubber Co., Western Ave., will rebuild its plant with brick and steel destroyed by fire.

**LORAIN**—The W. S. Automatic Co. will build a 2-story, 120-160 ft. addition to its plant. Estimated cost, \$100,000.

**TOLEDO**—The Nitrate Division, Bureau of Ordnance, War Department, Washington, D. C., has awarded the contract for the construction of nitrate plant No. 3, to the Air Nitrate Corporation, 360 Madison Ave., New York City. Cost will run into millions.

## Oklahoma

**DOLTHAT**—The Century Mining Co. will build a 150-ton concentration plant. Estimated cost, \$60,000.

**DOLTHAT**—The Douthat Miami Mining Co., Carden, will build a 200-ton concentration plant, requiring engines, boilers, sludge and slime tables, crushers, ore cars and bins. Estimated cost, \$60,000. Charles Douthat, superintendent.

**HOCKERVILLE**—The Bucksho Mining Co., 321 Hancock Bldg., Miami, will build a 150-ton concentration plant, requiring sludge tables, slime tables, engine and boilers. Estimated cost, \$60,000. Robert E. Brooke, superintendent.

**HOCKERVILLE**—The Lucky Jennie Mining Co. will build a concentration plant and install machinery including engines, boilers, etc. Estimated cost, \$60,000. W. F. Brooke, superintendent.

**LEADVILLE**—The Waxahachie Mining Co., Oklahoma City, will build a 150-ta concentration plant requiring sludge tables, crushers and conveyors. Estimated cost, \$60,000. J. Hare, manager.

**MIAMI**—The Aurora Mining Co., will build a concentration plant, requiring sludge and slime tables, ore crushers, motors, air compressors, belts, conveyors. Estimated cost, \$60,000. John W. Hale, superintendent.

**MIAMI**—The Indian Chief Mining Co. will build a 300-ton concentration plant. The company is in the market for sludge and slime tables, engines, boilers, engines and track cars. Estimated cost, \$75,000. John L. Sullivan, Miami, superintendent.

**MIAMI**—The Miami Mining Co., S. A. St. S. E., will build four 400-ton concentration plants. Estimated cost, \$250,000. J. P. Slaughter, superintendent. The company is in the market for sludge and slime tables, crushers, engines, boilers, air compressors and scales.

**OKLAHOMA CITY**—The Midland Motor Co. & Truck Co., 515 Mercantile Building, will build a 80 x 500 ft. factory for the manufacture of airplanes.

**PEORIA**—The Xebro Lead & Zinc Co. will build a 150-ton concentration plant, requiring slime and sludge tables, air compressors, engines, boilers, track cars, belts, conveyors and ore crushers. Estimated cost, \$60,000. R. C. Croslen, superintendent.

**PEORIA**—The Palative Lead & Zinc Mining Co., Miami, will build a 250-ton concentration plant requiring jigs, sludge and slime tables, ore crushers, etc.

**PICHEL**—The Commonwealth Zinc & Lead Co., Miami, will rebuild its mill here, destroyed by fire, and install machinery including drills, sludge and slime tables, ore cars and conveyors, crushers, belts, engines and boilers. Estimated cost, \$100,000. L. N. Dana, Joplin, Mo., superintendent.

**PICHEL**—The Miami Lead & Zinc Co., Miami, will build a 200-ton concentration plant and install machinery including hard-water sludge and slime tables and lumber for mill. Estimated cost, \$65,000.

**POTEAU**—The Poteau Window & Dry Plate Glass Co. will construct four buildings for the manufacture of glass for windows and photographic dry plates.

## Pennsylvania

**CONNELLSVILLE** — The McCairns Foundry Co. has awarded the contract for the construction of 60 x 65 ft. concrete and steel addition to its plant on the west side, to Cooper Patterson. Estimated cost, \$15,000.

**MIDLAND**—The Pittsburgh Crucible Steel Co., Empire Building, Pittsburgh, will build a mill here. W. G. O'Malley, manager.

**PHILADELPHIA**—The Barrett Manufacturing Co., Margaret and Bermuda Sts., has awarded the contract for the construction of a 1-story, 60 x 65 ft. concrete, brick and steel addition to its factory for the manufacture of coal tar products, to A. Raymond Raff Co., 1635 West Thompson St. Estimated cost, \$15,000.

**PHILADELPHIA**—The Gosa-Brockman Co., 12 North Fifth St., has awarded the contract for the construction of a 1-story, 60 x 62 brick and steel machine shop on Chestnut St. Estimated cost, \$15,000.

**PHILADELPHIA** — The Nitrogenous Chemical Co., 101 West End Trust Building, has awarded the contract for the construction of a 2-story, concrete and brick factory addition at Thirty-seventh and Tasker Sts. to Ernest Roth, 1541 Cabot St. Estimated cost, \$50,000.

**PHILADELPHIA**—The Super Glass Co., 3400 Disston St., will build a 1-story, 25 x 25 ft. brick factory addition at Howell St. and State Road.

**RUTHERFORD**—The Reading Railway Co., Atlantic and Arkansas Sts., Reading, has awarded the contract for the construction of a 1-story, 50 x 175 ft., brick machine shop here, to A. Woolfel, Lancaster. Estimated cost, \$50,000.

## Tennessee

**NASHVILLE**—The Southern Machine & Foundry Co., 213 Fourth St., S., will rebuild its plant lately destroyed by fire.

## Texas

**SAN ANGELO**—The Great Republic Tire & Rubber Co. will build a factory here. Estimated cost, \$100,000.

**WACO**—The Boone Tire & Rubber Co., c/o Chamber of Commerce, will build a factory for the manufacture of automobile tires and other rubber products. Roy E. Lane, Waco, architect.

**WICHITA FALLS**—Sunshine State Oil Co. has awarded the contract for the construction of an oil refinery, to the United Iron Works, Mill and Prospect Sts., Springfield, Mo. Estimated cost, \$150,000.

## Washington

**SEATTLE**—The Gulowen-Grel Engine Co., Alaska Building, has awarded the contract for the construction of a 2-story, 174 x 300 ft. factory on Salmon Bay Dock, to consist of a 174 x 300 ft. machinery and office building, 94 x 132 ft. foundry and 30 x 90 ft. pattern shop to M. Arson, Downs Block. Estimated cost, \$126,500.

## West Virginia

**MOUNDSVILLE**—The United States Smelting Corporation, Prisco Building, Joplin, Mo., will build a plant for smelting ore here. Estimated cost, \$1,000,000. C. E. Marshall, Joplin, manager.

## Wisconsin

**MILWAUKEE**—The National Brake & Electric Co., Bellevue and Cambridge Sts., will build a 1-story, 40 x 130 ft., concrete and brick factory. Estimated cost, \$22,000. Noted June 15.

**MILWAUKEE**—The Cutler-Hammer Co., St. Paul Ave., west of Thirteenth St., will build a plant. Estimated cost, \$6,000.

**MILWAUKEE** — The Globe Seamless Steel Tube Co., Colby-Abbot Building, will build a 1-story, 130 x 170 and 130 x 250 ft. brick and steel plant.

**SHAWANEE**—The Wolfe River Paper & Fiber Co. will build a 2-story, 165 x 50 V. addition to its mill. Estimated cost, \$5,000. L. A. DeGuere, Grand Rapids, engineer.

**SHEBOYGAN**—The Jenkins Machine Co., 315 North Eighth St., will build an addition to its plant. The company recently obtained a large war order.

**WEST ALLIS**—The Universal Machinery Co., 785 Thirtieth St., Milwaukee, will build a 1-story, 150 x 480 ft. machine shop here. F. E. Gray and Val A. Siebert, 86 Michigan St., Milwaukee, architects.

## British Columbia

**BEAVER COVE**—The Beaver Cove Lumber & Pulp Co., London Building, Vancouver, will build lumber and pulp mills here. Estimated cost, \$250,000. W. H. White, manager.

**VANCOUVER** — The Department of Mines, Dominion Government, Ottawa, Ont., will build ore testing plant. Estimated cost, \$60,000.

## Manitoba

**WINNIPEG**—The Hygiene Products, Ltd., 607 Young St., will build a plant here.

## Nova Scotia

**HALIFAX**—Robinson Co., Ltd., has awarded the contract for the construction of a brick and reinforced concrete garage and repair shop, to Maritime Construction Co., Queens Building. Estimated cost, \$50,000.

**STELLARTON**—W. P. McNeil will build a munition plant here. Estimated cost, \$60,000.

**SYDNEY**—The Dominion Iron & Steel Corporation, 112 St. James St., Montreal, Que., will build a steel rolling mill. Estimated cost, \$50,000.

## Ontario

**BRAMPTON**—The Hercules Rubber Co. will build a plant for the manufacture of automobile tires, etc. Estimated cost, \$60,000. Thomas Thauburn is interested.

**TORONTO**—The Gutta Percha Rubber Co., Ltd., 4 Yonge St., will build a factory on O'Hara Ave.

**TORONTO**—The National Iron Works, Ltd., foot of Cherry St., will build a 1-story, steel and galvanized iron addition to its factory. Estimated cost, \$15,000.

**TORONTO**—The Universal Tool Steel Co., 153 Dufferin St., will build a 1-story, brick addition to its machine construction plant. Estimated cost, \$45,000. G. C. Briggs, 27 Wellington St., E., architect.

**WILLAND**—The Metals Chemical Co. has awarded the contract for the construction of a plant for the manufacture of gunpowder to the Burns Cement-Gun Construction Co., Toronto.

**WINDSOR**—The Driver Harris Co., Harrison, N. J., has purchased a site here and will build a plant for the manufacture of all kinds of alloys. Estimated cost, \$60,000.

## Quebec

**COTE ST. PAUL**—The Crane Co., Ltd., Montreal, will build a plant for the manufacture of valves, fillings and a full line of plumbers' supplies, on St. Patrick St. Estimated cost, \$400,000. R. T. Crane, Jr., president.

**MONTREAL**—P. Lyall & Sons Construction Co., Ltd., 701 Transportation Building, will build a 1-story, brick forge shop, on Notre Dame St., E. Estimated cost, \$10,000.

**TRIMSKAMING**—The Riondon Pulp & Paper Co., 165 Beaver Hall Square, Montreal, will build a sulphite mill and power house here.



## Industrial Notes

**THE WILPUTTE COKE OVEN CORPORATION** announces the removal of its offices and engineering department to the Winfield Building, No. 469 Fifth Avenue, corner of 40th Street, New York.

**THE BOOTH-HALL COMPANY**, 565 West Washington Boulevard, Chicago, Ill., has made arrangements with the Bradford-Ackerman Corporation, 30 East 42d Street, New York, to take entire charge of sales in the eastern section of the United States.

**THE WESTINGHOUSE ELECTRIC & MANUFACTURING COMPANY**, Pittsburgh, Pa., has purchased the property, business and good will of the Krantz Manufacturing Company, Inc., Brooklyn, N. Y., manufacturers of safety and semi-safety electrical and other devices, such as auto-lock switches, distribution panels, switchboards, floor boxes, bushings, etc. The Supply Department of the Westinghouse Electric & Manufacturing Company will act as exclusive sales agent for the products of the Krantz Manufacturing Company, whose business will be continued under its present name. Mr. H. C. Hoke, of the Westinghouse Electric & Manufacturing Company, will represent the Supply Department at the Krantz Factory.

**HAMILTON & HANSELL**, Inc., New York, have recently contracted with the Government for two Rennefelt electric furnaces which will be installed at the United States Mint in Philadelphia, for melting bronze and cupro-nickel for coins. These furnaces are of the latest design, equipped with overlap tilting and automatic side electrode feeding mechanism. The 1000-lb. Rennefelt furnaces with its electrical equipment installed some time ago, is to be shipped to the Pacific coast and installed at the Mint in San Francisco.

**THE ALGOMA STEEL CORPORATION**, of Sault Ste. Marie, Ontario, is going to enlarge its by-product coke oven plant and a contract for an additional battery of twenty-five Wilputte ovens has just been let to the Wilputte Coke Oven Corporation, of New York City, making fifty new ovens now in process of construction. The two new batteries will probably be ready for operation this year.

**THE R. U. V. COMPANY, INC.**, announce that they have moved their New York office to 130 Broadway.

**THE WHEELER CONDENSER & ENGINEERING CO.**, Carteret, N. J., has under agreement with the Sugar Apparatus Manufacturing Co., acquired the exclusive right to manufacture and sell evaporating apparatus under the patents of the late John Lillie, president of that company. The advice of Mr. Lillie is to be at all times at the command of the Wheeler Condenser & Engineering Co. and at the same time Mr. Lillie will give cooperation of the entire engineering, sales shop and erecting organization of the Wheeler Company.

**THE ZAREBSKA COMPANY** announce the removal of the offices to Niagara Life Insurance Building, Room 1506, corner Franklin and Mohawk Streets, Buffalo, N. Y.

**THE MEXICAN PROMOTING AND INVESTING CORPORATION** have moved their New York office to 52 Broadway, Room 622.

**THE ELECTRON CHEMICAL COMPANY** are now located in Room 1403, 347 Madison Avenue, New York.

**PAPE TERMINALS CO.**, Wilfred N. Ball, Engineer, 225 First National Bank, Oakland, Calif., wants catalogs and other data from manufacturers of materials or equipment used in the construction of piers, warehouses, industrial buildings, b-h line, railway and street work and cargo handling equipment, coal bunkering and handling equipment, floating dry docks, marine railway equipment and general ship yard machinery and equipment.

**Government Contracts Awarded**—Contracts recently awarded by Ordnance Department of U. S. Army:

|                      |                        |
|----------------------|------------------------|
| <b>Material</b>      | <b>Firm</b>            |
| Fused calcium chlor- | Semet-Solvay Co.,      |
| ide.                 | Syracuse, N. Y.        |
| Lily white wax.      | Johnson Bros. &        |
|                      | Co., Philadelphia, Pa. |
| Oxygen gas and       | Burdette Oxygen        |
| cylinder.            | Co., Cambridge,        |
|                      | Mass.                  |
| Soda ash.            | Mathieson Alkali       |
|                      | Works, Provid-         |
|                      | dence, R. I.           |
| Sulphate of am-      | Illinois Steel Co.,    |
| monia.               | Gary, Ind.             |
| Benzol (packed for   | Barnes, N. Y.          |
| shipment abroad).    | York, N. Y.            |
| Smoke bomb outfits   | Gillespie Manufac-     |
| (pole type).         | turing Corpora-        |
|                      | tion, Washington,      |
|                      | D. C.                  |

**Chemical materials and supplies.**

**Ohio State University,** Columbus, Ohio.

**The Isaac Winkler & Bros. Co.,** Buffalo, N. Y.

**Diamond Alkali Co.,** Pittsburgh, Pa.

**Mathieson Alkali Works,** Providence, R. I.

**Ammonia compressors.**

**Triumph Machine Co.,** Cincinnati, Ohio.

**Condensers.**

**Triumph Machine Co.,** Cincinnati, Ohio.

**Soda ash.**

**Isaac Winkler & Bros.,** Cincinnati, Ohio.

**Picric acid.**

**Semet-Solvay Co.,** Syracuse, N. Y.

**Oxygen cylinders.**

**Tindell-Morris,** Edinboro, Pa.

**Salt peter.**

**Hercules Powder Co.,** Wilmington, Del.

**Caustic soda.**

**Winkler & Evans (Inc.),** New York City, N. Y.

**MR. C. H. VOM BAUR** has been elected vice-president of the T. W. Price Engineering Company. He has designed, operated and installed over thirty electric furnaces in this country, and is joint author of the book on "Electric Furnaces in the Iron and Steel Industry." This company has designed and installed new plants for the Lumm Steel Co., Watervliet, N. Y.; Hamm Steel Co., Syracuse, N. Y.; Century Steel Co., Poughkeepsie, N. Y.; Ulster Iron Works, Dover, N. J.; Hubbard Steel Foundry Co., East Chicago, Ind., and numerous others. The offices of the company are in the Woolworth Building, New York City, and 14 East Jackson Boulevard, Chicago, Illinois.

**THE RAINEY-WOOD COKE CO.** has been organized by the W. J. Rainey interests, operating coal mines and coke works in the Connellsville region, and the Alan Wood, Iron & Steel Co., with blast furnaces and steel works at Swedeland, Pa., for the purpose of constructing a large by-product coke plant of 330 ovens at Swedeland, Pa. The coal for this plant will be furnished by W. J. Rainey from their mines in the Connellsville region. Work has been started on the first unit of 110 of these ovens, and it is expected to have the plant in operation within fourteen months. This first installation will supply coke, gas and tar to the Alan Wood, Iron & Steel Co. and will have sufficient additional capacity to furnish foundry coke for the Eastern market. A complete by-product recovery plant will also be constructed for the purpose of recovering sulphate of ammonia and toluol to the U. S. Government. It is proposed to install the remaining units at the earliest possible date, in order to insure a continuing supply for the independent blast furnaces in the Schuylkill and Lehigh Valleys.

**THE INDEPENDENT FILTER PRESS CO., INC.**, has removed from 47 West 34th Street, New York, to 418 Third Avenue, Brooklyn, N. Y. The factories and office are now under one roof and the manufacturing is to be done under the supervision of Mr. A. C. Cuttler. Double the amount of machinery has been added in order to give prompt and quick deliveries.

## New Publications

**NEW BUREAU OF MINES PUBLICATIONS:**

Bulletin 110, Concentration Experiments on the Siliceous Red Hematites of the Birmingham District, Ala. By J. T. Singewald, Jr.; Bulletin 132, Siliceous Dust in Relation to Pulmonary Disease Among Miners in the United States. By J. T. Singewald, Jr. and K. Lanza, P. B. Laney and G. S. Rice; Bulletin 146, Technology of Salt Making in the United States. By W. C. Phalen; Technical Paper 118, The Interrelation of Moisture in Coke. By A. C. Fieldner and W. A. Selvig; Technical Paper 182, Plotation of Chalcopyrite-Pyrrhotite Ores of Southern Arizona. By W. H. Coghill; Technical Paper 183, New Views of the Combustion of the Volatile Matter in Coal. By S. H. Katz; Technical Paper 201, Accidents in Metallurgical Works in the United States During the Calendar Year 1916. By Albert H. Fay; Bulletin 151, Recovery of Gasoline from Natural Gas by Compression and Rectification. By W. P. Dykema; Technical Paper 185, Use of the Interferometer in Gas Analysis. By Frank M. Seibert and Walter C. Harpster; Technical Paper 202, Metal-Mine Accidents

in the United States during the Calendar year 1916. Compiled by Albert H. Fay; Bulletin 149, Bibliography of Petroleum and Allied Substances, 1915. By E. H. Burroughs.

**NEW BUREAU OF STANDARDS PUBLICATIONS:** No. 321, Thermal Expansion of Alpha and Beta Brass Between 0 and 600 deg. C., in Relation to the Mechanical Properties of Heterogeneous Brasses of the Muntz Metal Type. By P. D. Merica and L. W. Schrad, issued May 4, 1918; No. 104, Effect of the Size of Grain in Fire-Clay Bodies. By F. A. Kirkpatrick, issued March 12, 1918.

**CIRCULAR LETTER VIII-4**, giving a working bibliography of reference and handbooks on the properties of metals and alloys. This circular has been prepared in answer to numerous requests for general and comprehensive information and can only be answered with the statement of the sources where such information can be obtained.

**TANNING MATERIALS OF LATIN AMERICA.** By Thomas H. Norton. Copies of the report can be obtained from the Superintendent of Documents, Washington, D. C., or to any of the District Offices of the Bureau of Foreign and Domestic Commerce.

**AN INDUSTRIAL SURVEY OF SEATTLE.** By Curtis C. Aller. Bulletin No. 3, issued by the University of Washington, Bureau of Industrial Research, Seattle, Wash.

**FUEL ECONOMY IN THE OPERATION OF HARBOR-REAR STEAMERS.** Circular No. 1, published by the University of Illinois, Urbana, Ill. Price \$0.20.

**MINING ENGINEERING AS A PROFESSION.** A publication of the University of Arizona, College of Mines and Engineering, Tucson, Arizona.

**THE HARRISON WORKS**, paint and chemical manufacturers owned and controlled by E. I. du Pont de Nemours & Company of Wilmington, Delaware, have just issued six booklets as follows: "Harrison Blue Ribbon Chemicals," "Harrison Oil Paint," "Harrison Oil Stains," "Harrison Automobile and Carriage Paint," "Harrison Porch Chair Enamel" and "Shingle Homes." Copies may be had upon request.

**EMERGENCY WAR TRAINING FOR AIRPLANE MECHANICS.** Bulletin No. 12, issued April 1918, by the Federal Board of Vocational Education, Washington, D. C.

**"MANUFACTURING OPPORTUNITIES IN THE STATE OF WASHINGTON"** has just been issued by the State Bureau of Statistics and Immigration, State of Washington, Olympia. Copies may be had upon application.

**THE UNIVERSITY OF IDAHO**, Moscow, Idaho: Vol. XIII, No. 1, which is the annual catalog for 1917-1918 issued May, 1918, with announcements for 1918-1919.

## Manufacturers' Catalogs

**P. H. & F. M. ROOTS COMPANY**, Connersville, Ind.: Catalog 63 illustrating and describing rotary gas exhausters for foul gas pumping service, corrosive gas handling with high-pressure booster service and special devices.

**J. P. DEVINE COMPANY**, Buffalo, N. Y.: Bulletin No. 105A, which describes and illustrates apparatus for the color, chemical, dyestuff and allied industries. Copies of this bulletin can be had by applying to the above company.

**BUFFALO FORGE COMPANY**, Buffalo, N. Y.: Section No. 108, March, 1918, covering stationary forges.

**COMPUTER MFG. CO.**, 25 California St., San Francisco, Calif. A booklet on the Ross precision computer which is said to be equivalent to a slide-rule 100 feet long.

**THE BRAUN CORPORATION**, Los Angeles, Calif.: Catalog No. 50 on the Braun laboratory appliances, describing and illustrating the many different types.

**THE BROWN INSTRUMENT COMPANY**, Philadelphia, Pa., has just issued an interesting chart printed in four colors showing the melting points of chemical elements, together with a heat-color scale giving a useful conversion table of Fahrenheit and Centigrade degrees. The color-scale includes 50 elements from nitrogen to carbon, and should be found valuable in all kinds of heat treating work.

**THE COLORADO FUEL & IRON COMPANY**, Denver, Colorado: Industrial Bulletin, Vol. III, No. 3, April 30, 1918, which contains articles of timely interest for the information of their employees.



# CHEMICAL & METALLURGICAL ENGINEERING

A consolidation of ELECTROCHEMICAL & METALLURGICAL INDUSTRY and IRON & STEEL MAGAZINE

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### Economics of Prices and Production in War Time

PROBABLY every engineer has, at some point in his education, gained at least a smattering of the science of economics. If his experience coincides with ours, his study of the subject was rather superficial, due to pressure of other work deemed more important, and his recollection of it is confined to a few hazy notions on the law of supply and demand. As a logical consequence he is likely to be a bit confused when the subjects of price-fixing and *laissez faire* are expounded by their proponents as cures for the economic evils that beset us in war times.

It is with a view to clarifying the situation somewhat that we have asked Professor McCrea of Columbia University to write a brief exposition of the economics of prices and production in war times. His article appears elsewhere in this issue, and we believe engineers generally can afford the time necessary for its study, and that they will feel repaid for the effort. Professor McCrea has picked illustrations and phases of the subject appropriate to the engineering profession.

### Buying a Scientific Pig in a Poke

IT IS doubtful if any organization other than Congress could have been induced to heed the representations of a comparatively unknown scientist on the mere claim that he had a mysterious and wonderful machine for the development of energy. Congress does some things well, but when it dabbles in science and engineering it is likely to make a poor showing.

For some time now we have been awaiting the revelations promised by Garabed T. K. Giragossian as a result of official encouragement granted him for the development of whatever it was he had in mind when he induced Congress to back him. The report of the investigation committee, composed of four Massachusetts Institute of Technology scientists and a fifth engineer, is brief and negative. It is about what all engineers anticipated, certifying that the model was not in shape to run or develop power; also that "the inventor admitted that he had no working machine and that he was merely explaining principles." Apparently the "principles" did not satisfy the committee, because they are dismissed as unsound, and the device is discredited as inoperative. In short, the bubble burst when exposed to mere inspection.

The inventor is reported to be undismayed, and still determined to demonstrate his idea and force its acceptance by an unwilling and ungrateful government. The sooner the incident is dismissed and forgotten, the

less likely it is that other inventors of perpetual motion machines will seek the ear of Congress and implore official recognition. We hope the time will come when sound engineers can get as much recognition on their merits, as fanciful dreamers secure through persuasive powers of speech and glittering promises.

### Administering Alien Property

**I**N taking over the vast amount of enemy alien property by the United States Custodian we have been very favorably impressed with the high class of men who have been appointed as administrators. The majority of names, which at first glance are familiar to us, are those of gentlemen who have successfully administered estates of immense value either as owners, trustees or corporation officers. We do not observe, however—and we say this subject to correction for not having the complete list before us—names of men having the technical training to understand the nature of the business which they have in hand, in chemical manufacture.

Now, chemical industry does not accord with the convention which became established in the joyous old days, to the effect that given a factory with machinery, a lot of workmen and a superintendent, it was bound to succeed if only the members of the board of directors were all successful men. It doesn't work that way at all. A banker, a broker, a street railway magnate, a dry goods merchant and a lumber king, no matter how rich they may be, are not the right persons to make chemical products or to sell them. Their time is worth too much to waste it in doing nothing, and the mere formality of attending board meetings without understanding what is going on, is waste. It is chiefly in German-owned works that many enemy aliens are employed as managers and superintendents as well as technicians. Therefore we hold that at least one member of each board of directors of every German-owned chemical works should be an American chemist of high standing. Otherwise, no matter how competent the board is, the insiders may put something over on the directors that will only be discovered after it is too late.

Enemy property should be conserved, and properly conserved, because as a people we still remain civilized, and if we hold our heads high and keep up our faith, German depravity will not spread its infection among us. But as to the wisdom of the appointment of men of technical training to these boards, we think it important, and we urge it upon the Custodian of Alien Property. There are many reasons why it should be done, and we know of none to the contrary.

### What Does the Employer Expect of the College-Trained Chemist?

**W**ITH the purpose of gaining the point of view of the manufacturer regarding the qualifications which lead the college-trained chemist to a successful career and rapid promotion, the *Kansas Chemallurgist* sent out enquiries, some of the replies to which are printed in the May issue. The general consensus of opinion was that personal characteristics were equally as essential for stepping to the front of the ranks of the chemical profession as pure scientific knowledge and training. Such qualifications as honesty, initiative,

imagination, enthusiasm, persistence, aggressiveness, tact, loyalty and progressiveness were cited with emphasis. One writer thought these qualities should not be regarded as gifts, but as the acquirements of a properly directed mind which became natural, just as any physical habit does, by practice.

Dr. W. R. Whitney of the General Electric Co. may well be quoted: "We expect of each man at the start certain definite things, but when he does only what we expect from him, he does not get along as rapidly or as well as when he exceeds our expectations, and that is the kind of man to train, if possible. For example, a man trained as an analytical chemist may be added to the force. It is satisfactory if he is and remains a fair analytical chemist, but it almost always happens that opportunities come to him for extensive or special work. It may be no more than extensive development of the appreciation of the uses of analytical chemistry in our field. Or it may be that, because of his particular interest or enthusiasm, he develops into an expert in some line, such as electric-furnace products, tool-steel manufacture, etc. The actual manipulation necessary for the chemist in the analytical field as applied to our own experience is not difficult enough or rare enough to warrant high salaries, except where it is combined with what may be called interpreting powers. An analytical chemist who actually performs all the analyses needed in a running laboratory, but does nothing else, can seldom be paid a decent salary, because there are so many of them."

Without doubt, the chemist who gets the coöperation of his associates and has the power of uniting his forces in their best formation for attacking his work is just as much of a leader as any of our executives, civil or military. To do this, he must have character, the more important attributes of which have been mentioned. The employer seeks the man that can promote the welfare of the firm and be promoted himself in return. To do this, he must have the correct point of view and the will to execute his conceptions. Then he will always produce the desired results.

### Post-War Problems in the Chemical Industry

**I**N RECENT issues of *CHEMICAL AND METALLURGICAL ENGINEERING* we have been directing attention through a series of articles by our Washington representative to the imperative necessity of beginning at once to plan for the reconstruction of our industries after the war. The inevitable readjustment that will be necessary when peace comes should be anticipated by the best minds in the industry so that the change will be made with as little dislocation as possible.

It must be evident to all that our chemical industry, being basic in the production of munitions of war, has undergone tremendous expansion. Production far exceeds anything known or needed before the war, and the troublesome question arises, What are we going to do with our production when the abnormal demands of war no longer exist? The answer will not be so difficult in the case of those chemical products which are new to this country and which will supplant former importations; but in the case of acids and alkalies, chlorine, ferro-alloys, air-nitrates and some other products in

which we have had a tremendous expansion there will be need of careful and constructive thought. The use of these materials must be extended in proportion as their production has expanded or there will be economic loss and waste.

Great Britain already has approached the problem of sulphuric acid overproduction, and the makers have been in conference on the advisability of forming a National Sulphuric Acid Association. Recommendations have been made looking toward the use of excess acid in the manufacture of fertilizer and the more extended use of that material. Vitally and intimately related to this program are the subjects of cheap transportation, education of the farmer, equitable taxation and a scheme for the scrapping of useless plants. The cooperation and support of the Government is sought and expected.

In our own country we have such agencies as the Chemical Alliance and the American Chemical Society which should take the initial steps toward protecting our chemical industry when peace comes. Both organizations are directed by leaders in the industry, and are favorably situated to sense its post-war problems. Investigations should be started at once, preferably by men whose minds are free from concern with the problems of present production. A symposium on the subject at the Fall meeting of the American Chemical Society should be of inestimable value if properly organized.

### Profits and Profiteering

THE Federal Trade Commission's report on "profiteering" was made public June 29 and immediately there arose a storm of criticism in many branches of the trade press. Perhaps if the Commission were afforded an opportunity to comment upon the editorials that have been written about its report it would find as much occasion to criticise the editorials as the editors found to criticise the report. It could take advantage of the editors in one respect, by giving the editorials the careful reading it is evident some of the editors did not give the report.

The report has been dubbed "extraordinary," for instance, but that is not particularly remarkable in a report on a practice that is so extraordinary that its very name has not hitherto been recognized by the lexicographers. It is suggested also that the report reminds one of the "muckraking" days. A careful reading of the report, however, from the viewpoint of the circumstances which moved the Senate to call for it, does not indicate that it is such a remarkable document after all. The chain of circumstances that led to it was short and closely linked. On May 27 the President appeared before Congress and asked that the session be prolonged to consider the taxation program for the calendar year 1918, four billions having been the estimate for the taxes levied against 1917, while the amount would have to be increased greatly. The President said:

"There is abundant fuel for the light in the records of the Treasury with regard to profits of every sort. The profiteering that can not be got at by the restraints of conscience and love of country can be got at by taxation. There is such profiteering now and the information with regard to it is available and indisputable."

The Senate accordingly called upon the Federal Trade Commission for a report giving such information as the

Commission had available as to how profiteering could be got at either by taxation or by enactment of more effective criminal statutes. The Commission in its report, however, does not propose any additional criminal statutes, but rather reports that there are cases of men violating existing law, and that "The Federal Trade Commission has been vigilant and untiring in its exclusion of these practices." It does point out that there are large profits, and that is precisely what Congress desired to find. That is not a hallucination on the part of the Commission, not even a new discovery. When price-fixing was being discussed, about a year ago, it was the common contention of producers that the most efficient method of procedure for the Government would be to allow large profits, and then tax those profits as far as necessary. Perhaps it was poor advice, but at any rate it has never been formally withdrawn.

The Commission deserves much credit for bringing out strongly a very practical and important fact in connection with profits and production, and that is that in a given industry there are likely to be large profits and small profits, from which the Senate will experience no difficulty in deducing that the efficient thing is to tax profits on a graduated scale rather than reduce prices until the profits of the more efficient producers become normal and the profits of the less efficient are converted into losses causing them to cease production.

Criticism of the Federal Trade Commission's report, rather a tame document on the whole, but marked by some lurid language which is not illuminating and had much better have been omitted, apparently loses sight of the fact that the Commission has had an important part in the fixing of prices, being constantly consulted by the War Industries Board and the President. If it desired any general scaling down in prices its representations would have been made in those quarters and would not have been held back for presentation to the legislative body when the latter is seeking profits upon which to levy taxes.

On the whole, the report clears the situation somewhat, though to no great extent. It is more important in what it does not say than in what it does say, except as to the one point that it emphasizes the fact that profits vary greatly among the different producers in an industry. Congress can now forget about "profiteering," for which there is no precise definition, and address itself to the taxing of "excess profits" or "war profits" which can be defined precisely, in dollars and cents, in various ways. The law taxing 1917 profits defined the excess by a scale of percentages based on capital investment. The original House bill had taken the average profits of 1911-12-13 as a basis. Lately the British system has been proposed, based on the two best of those three years. The President told Congress that the present tax laws "are marred, moreover, by inequities which ought to be remedied," and yet it appears the taxes were computed and paid without a great deal of difficulty. It has always been a debatable question how much capital the United States Steel Corporation has invested, yet although the tax is based on capital investment it appears that the Corporation paid precisely the tax it computed before the time had arrived for it to make its taxation report to the Treasury Department. The prospects are that a suitable tax law will eventually be enacted.



## Readers' Views and Comments

### Molecular Physics of Ore Flotation

*To the Editor of Chemical & Metallurgical Engineering*

SIR:—I would like to correct a misstatement by Coghill and Anderson in their recent article entitled "On the Molecular Physics of Ore Flotation."

This statement is as follows:

Other writers have made similar attempts (calculation of capacities) by using principles incorrectly. The most striking case is that of Van Arsdaale. He begins with the promise that "the maximum weight that can be supported on the surface of water is equal to the surface tension of the area supporting the weight." Beginning thus with a false premise naturally he ends with false conclusions. It is scarcely hypercritical to say that for these fallacies to go unchallenged, after receiving favorable editorial comment and being incorporated in a book, portends a tardy science of flotation.

The portion of my article referred to read as follows:

We can then ask the question, How and why does a particle heavier than water float on a water surface? and if we can answer this we can expect considerable light on the whole subject. It is obvious enough that if a needle or anything else specifically heavier than water floats it does so primarily because of the effect of surface tension.

Now if this is true, there should be a relation between surface tension factors and the maximum weight that we can support on a water surface, and if we can experimentally verify such a relation we can consider our assumption proved.

It has been stated that the maximum weight that can be supported on a surface of water is equal to the surface tension of the area supporting the weight: that is to say that one square centimeter will support about eighty-one milligrams. As a matter of fact it can easily be shown that a square centimeter of water will support much more than this weight. We can however derive the relation we are after from the surface tension formulas for the difference in pressure between two sides of a curved surface. By the use of these formulas we can calculate the maximum size of cylinder that will float, and can verify our hypothesis experimentally by floating, for example, clean copper wires of various sizes. The maximum size of copper wire, when calculated thus, is about seventeen or eighteen B. & S. gage, depending on the area of contact. By careful manipulation we can float a wire of a size very close to that calculated, and can therefore be sure that our hypothesis is correct.

At the time my article appeared there were several flotation "theories" and the object of my argument was to show that flotation was due primarily to surface tension. This may seem superfluous now in view of our increased knowledge of the subject, but at that time flotation was popularly a "mystery."

It is, I think, obvious from my article as quoted above that I do not use the statement quoted by Coghill and Anderson as a premise at all but do prove that the statement is wrong, and that a close approximation to the maximum weight of a particle of either spherical or cylindrical shape that can be floated can be calculated by the use of the formulas given. A correction was later made of a transposed formula, but the conclusion I think remains correct.

It was distinctly stated in the article that details were not gone into and the figure given therefore of about seventeen gage copper wire as the largest size capable of flotation was only approximate, and furthermore as stated the size depends on assumptions made as to the amount of wet surface. The object of the

argument was not to determine an exact size of particle but to prove that surface tension was the primary cause of flotation, and not more or less obscure "electrostatics." The agreement between the calculated figure and that experimentally obtained while possibly not so exact as that obtainable by more elaborate methods was sufficiently so for the stated purposes of the argument.

In any case I think it will be clear from the above that the authors of the present paper were not warranted in making the statement that I used as premise the obviously incorrect statement given, but on the contrary this is distinctly given as a quotation and is proved to be wrong.

G. D. VAN ARSDALE.

Douglas, Ariz.

### The Recent Flotation Decision

*To the Editor of Chemical & Metallurgical Engineering*

SIR—It appears that the U. S. Circuit Court in California has overruled the District Court in Montana, and concluded that the Supreme Court did not mean 1 per cent of oil or fractions thereof, but  $\frac{1}{2}$  per cent of oil and less.

The California Court in substance decides that extra-neous oil added for no purpose other than to avoid infringement may be classed as process oil and considered as oil desirable or useful in flotation results. The issue is forgotten, or not understood, that the essential oil in kind and degree, as described in the flotation patents at issue, is used to obtain the results, and that the extra-neous oil is a neutral non-essential grade, not improving results but rather hindering them.

If it were shown by defendants that there was advance in the art, or a new process discovered by the use of oil, in any way, in excess of 1 per cent or even in excess of a fraction of 1 per cent, then the ruling of the California Court would be understandable. As it is, there appears no reason to doubt that the Supreme Court will again rebuke the California decision and stand on the broad ground it has taken, that the patents of Messrs. Sulman, Picard and Ballot are valid and must be broadly sustained.

If new evidence is shown, not now known to the profession, there is of course a chance to nullify the invention of Messrs. Sulman, Picard and Ballot as anticipated by prior art. If invention can be shown by advances in the art as described and practised under patents of Messrs. Sulman, Picard and Ballot, then a new flotation invention exists that may have individual standing.

I was called upon to give opinion in this issue prior to the Supreme Court decision, and I maintained that the Delaware Court must be sustained by the Supreme Court as it was. When the issue was started afresh regarding the use of excess oil to avoid royalty payments, I maintained that the Court must decide that the process of Messrs. Sulman, Picard and Ballot was still being used, no matter what excess of foreign matters like neutral oil existed, unless a new flotation process could be shown, with results that were not obtained solely by the use of the minor fraction of suitable oil

and the proper degree of agitation, as called for by patents mentioned. The Montana courts did so find, and I trust I may be permitted to again express opinion, for the issue to my mind has always been very clear.

There appears a lot of camouflaging and irrelevant matter in opinions expressed that, like the California decisions, show the minds do not grasp the real issue. The fact is that a commercial advance was created by the process of Messrs. Sulman, Picard and Ballot and was at once grasped by industry with immense profit. We may also say that unfortunately the patents were exploited for gain rather than administered by the inventors or a research board, but while this fact may excite opposition and litigation, it cannot change the legal status. Custom has devised no other form of meeting the money power of industry.

The Supreme Court recognized invention, saw the large benefit to community interests, the object of our patent laws, and saw that the process was one of degree and hard to define. In using the 1 per cent of oil definition of degree, the Supreme Court sustained the reading of the claims as a liberal interpretation, and it will be found that the use of much more than 1 per cent of oil will not break the patent protection, unless some new process or result is obtained thereby, and the burden of proof will be upon the inventors of this new process to prove it, which has not been presented.

It seems to me that the opinions and editorials I read are discussing words rather than issues and I can see no purpose in discussing the per cent of oil without the results and purpose of that oil, and as to the use of the term "critical" I feel that it was a fair term to use, when used in the light of the kind of oil and condition of agitation. It will be ruled that the per cent of oil has little bearing on the issue so long as the active oil that does the work is a fraction of a per cent which has been true up to the present.

The Supreme Court must protect invention that is the basis of community advance, and thus patent law; and in order to avoid royalties to owners of the Sulman, Picard and Ballot patents industry must show that results are not obtained by the critical conditions demonstrated by those patents. If Messrs. Sulman, Picard and Ballot were not the first to demonstrate, then the patents may be vacated, but on no other grounds.

PARKER C. CHOATE.

Essex, Mass.

## The Microscope in Ore-Dressing

To the Editor of *Chemical & Metallurgical Engineering*

SIR:—Having read with interest the article, "Approximate Determination of the Minerals in Concentrates by Means of the Microscope," by Kirby Thomas and Frederick W. Apgar, I am enclosing a brief outline of the use of the microscope in the Missouri School of Mines Laboratories. This outline was written some years ago so does not mention the article above noted.

This outline under methods No. 1, 2 and 4, shows three uses which Messrs. Thomas and Apgar do not consider. In method 2 the microscope had been found very helpful as the disappearance of the middling can be readily noted and the most economical size for crushing can be determined. In performing some experiments on the flotation of copper carbonates after

sulphide-filming I have found the microscope especially valuable for noting the efficiency of various filming methods. Material that is sized between close limits lends itself more readily to a microscopic examination than unsized material. Very often a slight panning in a watch glass will aid. Material through 260-mesh can readily be examined if the fines are removed by panning.

Numerous articles have appeared from time to time on the use of the microscope in petrography, metallography and qualitative chemistry, but no mention has been made of its use in ore-dressing.

The microscope can be used to advantage for at least four purposes, namely:

1. The determination of the mineral constituency of an ore that has been crushed.
  2. In conjunction with a set of standard sieves for the determination of the critical diameter of an ore (the diameter of grain that shows all free mineral, no middling).
  3. In obtaining an approximate analysis of the products of various concentrating machines.
  4. Measuring the size opening in screens.
- In explaining the above uses the subject will be discussed under the following heads:
- a. Instrument used.
  - b. Source of light.
  - c. Magnification.
  - d. Methods of making determinations.

a. *Instrument Used.* The instrument used is the Bausch and Lomb metallurgical microscope with mechanical stage. Any instrument could be used, but there is a decided advantage in using the mechanical stage having lateral movement in two directions as well as vertical movement. The binocular microscope is good for comparing specimens.

b. *Source of Light.* Good sunlight has an advantage over artificial light and is best reflected upon the material from above, as light from below does not give good illumination. If the day is dark, it is best to use artificial light. The strength of light needed is determined by the magnification used. A plain 60-watt lamp is best for low magnification; a Nernst or Leitz lamp with bull's-eye condenser for high magnification.

c. *Magnification.* Low magnification from about 20 to 80 diameters serves best for general purposes. In studying products from fine screens and fine products in general, higher magnification is better. A little practice in this work soon determines what combination of lenses it is best to use.

### d. Methods:

1. *Mineralogical Analysis.* For this work the ore is panned and dried; both products are put on small watch-glasses, placed under the microscope and the light adjusted. It is very easy for one with a knowledge of mineralogy to distinguish minerals, at least the more common ones as galena, blende, quartz, calcite, etc. With a little work one could be able to distinguish a larger variety. The knowledge of the ore gained by this analysis will aid more in working out various mill processes than will any qualitative chemical analysis or mineralogical analysis of the lump ore.

2. *Critical Size.* In this determination the procedure is more tedious, as a screen analysis followed by a

thorough microscopic analysis is required. The operation is as follows: After making the screen analysis take the product from each screen, mix intimately, place on a small glass slide under the microscope and make all adjustments. By careful examination the mesh at which all the particles of valuable mineral are set free from gangue and from each other can be determined, and, by counting, one can determine the ratio of these particles on each screen.

3. *Approximate Analysis.* Take a sample of the various products such as head, concentrate, middling, or tailing while the machine is working, place on a watch-glass and examine while wet for a hurried result, or dry on a hot-bath for a more careful study. In a very few minutes one can note exactly what work a machine is doing by noting the ratio of gangue particles to particles of valuable minerals.

4. *Measuring Screens.* By placing the screen to be measured under the microscope and using a calibrated Filar micrometer one can very quickly determine the diameter of the hole and the wire as well as the character of the wire. Very often a screen with supposedly square openings shows holes that are of many different shapes.

Of the above methods suggested the approximate analysis of products from concentrating machines offers the largest field for the use of the microscope because here the instrument is a time saver for the experimenter as well as for the chemist. The products to be examined include sands and slimes from various types of machines such as tables, vanners, stamps, fine crushers and flotation machines.

Flotation offers a very big field, for in testing the amenability of certain ores to the process, we must determine the effect of numerous variables, including the effect of hundreds of oils. In testing, as well as in actual working machines, we get a froth which is the concentrate. This froth is very deceptive as to its mineral worth and without a microscope a visual analysis does not always suffice, so when a microscope is not available it is necessary for the chemist to make the proper determination. In testing an ore the chemist will have some 500 to 1000 determinations to make, 80 per cent of which could be eliminated by the use of a microscope. Not only could a large part of the chemical analysis be done away with but the experimenter in examining the froths could study more closely the work of the machine and the nature of the process.

The testing with a microscope is only the work of a few minutes and can be done on the wet ore if the results need not be accurate; or upon the dry ore if a more accurate check is desired. The manipulation is as outlined under method number three.

It is to be remembered that this work is only as accurate as the operator makes it, the degree of accuracy of course being limited and depending upon the experience of the operator.

The above suggestions as to the uses of the microscope in ore dressing are not by any means all new ones, but it is hoped that these may prove interesting as well as useful to those who are less familiar with the microscope.

CHAS. Y. CLAYTON.

Missouri School of Mines and Metallurgy,  
Rolla, Mo.

## Copper in Converter Slags

*To the Editor of Chemical & Metallurgical Engineering*  
SIR—The editorial in the April 15 number of METALLURGICAL AND CHEMICAL ENGINEERING on "Copper in Converter Slags," is very interesting, and one that should bring out some discussion from metallurgists who have to solve the problem of cleaning converter slags.

I herewith give the results of some experiments made by me on the pouring of converter slags into blast furnace settlers which may be of interest.

|                                                        | Copper<br>Per Cent |
|--------------------------------------------------------|--------------------|
| Experiment No. 1.                                      |                    |
| Furnace and converter slag, proportions 1:1 assay 0.61 |                    |
| Furnace slag alone .....                               | 0.31               |
| Difference .....                                       | 0.30               |

|                                                         |      |
|---------------------------------------------------------|------|
| Experiment No. 2.                                       |      |
| Furnace and converter slag, proportions 2:1, assay 0.53 |      |
| Furnace slag alone .....                                | 0.41 |
| Difference .....                                        | 0.12 |

|                                                         |      |
|---------------------------------------------------------|------|
| Experiment No. 3.                                       |      |
| Furnace and converter slag, proportions 3:1, assay 0.54 |      |
| Furnace slag alone .....                                | 0.40 |
| Difference .....                                        | 0.14 |

|                                                         |      |
|---------------------------------------------------------|------|
| Experiment No. 4.                                       |      |
| Furnace and converter slag, proportions 4:1, assay 0.63 |      |
| Furnace slag alone .....                                | 0.47 |
| Difference .....                                        | 0.16 |

These experiments were checked several times, and showed that the converter slag was not cleaned below approximately 1 per cent copper by this method which together with the fact that the excess iron contained was valuable as a flux, finally resulted in all the converter slag being resmelted in the blast furnaces, the limestone being taken off the charge, and both costs per ton of charge and metallurgical losses materially reduced. At first the converter slag was spilled on the ground and picked up by hand labor, but this was afterwards changed to simply spilling it in thin layers on the ore in the pits as the beds were being built for smelting, the plant lending itself peculiarly to this method of handling the slag.

Most metallurgists will, I think, admit that converter slags cannot be cleaned without resmelting them, and in doing so, changing the chemical composition, but it will be interesting to get the experience of those who have had to treat them by other methods and especially of those who, on account of their plants are forced to spill the slag into reverberatory furnaces.

FOREST RUTHERFORD.

New York City

[We invite further discussion of this interesting subject.—EDITOR.]

## Condensation in Electric Zinc Smelting

*To the Editor of Chemical & Metallurgical Engineering*  
SIR—In your issue of May 15, 1918, page 540, in the article on Fulton's Electric Zinc Furnace, the following didactic statement is made: "Several designs of electric zinc furnaces can produce zinc vapor in large quantity, but none of them has been able to produce the proper yield in liquid metal." I have no knowledge of how inclusive the said "several designs" may be; but



as the evident intent is to convey the impression that the Fulton furnace, or its condenser, is the first to successfully accomplish the indicated result, I beg the privilege of informing you that this is not in accordance with the facts.

For some ten or more years past, I have been engaged as a principal in the design and development of electric furnaces for reducing zinc ores, complex and oxidized the principal work being carried on in Europe, or until suspended by the war. Hundreds of tons of high-grade zinc was produced, the condensation being approximately completely in the form of liquid metal. The reduction was according to the classical formula



More recently, or about two years ago, I designed and caused to be built and operated an electric furnace and condenser for refining impure spelter by re-distillation. The overall dimensions of this unit, in plan, were about 5 x 8 feet, height 4 feet, and it was run for months continuously with a regular output in refined zinc of 2,500 pounds in 24-hours, and in one case at the rate of 3,600 pounds. The condensation was complete to liquid metal.

Incidentally, the upkeep cost was *nil*. The electric energy required for this operation ran from about 0.5 to 0.6 kw.-hr. per pound of refined metal and in a regular "going" operation could probably be reduced to 0.4 kw.-hr., which is sufficiently near to the theoretical limit, as in "the books," to be dubbed good enough.

That the work was carried through with care, skill and intelligence, and with a docket record which is complete, goes without saying in that it was conducted by Mr. F. A. J. FitzGerald, E.E., at his laboratories, Niagara Falls, N. Y.

The project, as relates to zinc-smelting, has not as yet been exploited in this country, nor am I seeking by this means to advertise it; the limited details herein set forth are presented simply to accentuate the point that a little condensation of such a sweeping statement as you stand sponsor for would appear to be in order in the interest of accuracy and fairness.

JOHN THOMSON.

New York City

## Special Gold-Recovery Processes

To the Editor of Chemical & Metallurgical Engineering

SIR—In your issue of June 1 Mr. Kirby Thomas calls attention to the fact, reported by John Mawe a century ago, that Brazilian natives mixed the juice of certain bruised herbs with the water in which they finished the panning of gold from black sand, and also mentions the addition of the leaves of an oak-like tree to *tahones*, or primitive Chilean mills, used for grinding ore in Sinaloa, Mexico. This use of plant juice to facilitate the settling or concentration of "float" gold has been mentioned by several other writers.

Volume 20 of the Proceedings of the Institution of Mining and Metallurgy (1911) contains two papers on the Passagem and Ouro Preto mines in the province of Minas Geraes, Brazil. One of these, by R. H. Kendall, describes (pp. 28-60) the modern treatment of the bismuthic gold ore of Ouro Preto by stamp-milling and concentration on blankets followed by Frue vaners. The very rich blanket concentrate (largely free

gold) is re-washed over a small blanket, yielding a final concentrate carrying about 80 per cent gold. "The water used in this operation is a solution containing the juices of the leaves of the *jurupeba*, and is very effective in preventing float gold. . . . At the end of each day's operation the *jurupeba* solution is filtered off by suction and stored for next day."

In discussing this paper, H. L. Sulman, president of the Institution, called attention to the use of this herb—presumably containing saponin—which he interpreted as reducing the surface tension of water. Sulman, by the way, was an oil and soap chemist and an early experimenter in flotation, who had previously patented the use of soap solution for settling float gold and slime (Brit. pat. 24,939, of 1893 and 8,405 of 1894). The plant was stated to be *Solanum paniculatum*, of the nightshade or potato family, and also locally called *hera de sabão* (soap plant). Other plants, including a variety of passion-flower, were also said to be employed for the same purpose in the district referred to above.

The same thing had also been recorded by Alexander Calcleugh ("Travels in South America, 1819-1821"; published in London, 1825). A. G. Lock ("Gold", p. 227) says: "The overseer showed Calcleugh some plants whose juice is squeezed into the bowls containing gold, to carry down the lighter particles. There were several plants in common use for this purpose, but the one generally preferred, from its containing more juice, was called *itabamba*; it appeared to be a *Solanum*. The leaves had a bitter taste and gummy feel." This was at a place one league from Passagem.

In the Philippine Islands a pod-bearing vine (*Entada Purusaetha* or *Entada scandens*, called *gogo* or *balogo* by the natives) is used in panning gold with the batéa. This contains saponin and was the subject of an investigation and report by the Philippine Bureau of Science a few years ago. It was also mentioned by Lock ("Gold", p. 368).

Something similar has, I believe, been reported as used by the native gold-washers of Sarawak (Borneo) and Sumatra; I have also heard vaguely of an herb used by Mexicans in California and Lower California. The latter is probably one of several well known liliaceous plants called soap-root or *amolè*, the roots of which contain enough saponin or allied substance to lather freely with water.

Saponin as an anti-flotative agent has been discussed to some extent by Hoover, Rickard, and other writers on flotation. It evidently occurs in plants differing widely in character and distribution, which include the horse-chestnut and the numerous soap-roots, soap-barks, soap-berries, etc. Its application to float gold appears from the above to be confined to people of a relatively low stage of civilization. It would be interesting to ascertain whether such remote races as the Brazilians and Filipinos discovered it independently, or whether, as Mr. Thomas suggests by the heading of his letter, they both learned its use from the early Portuguese or Spaniards who employed them in mining. That it "works" is evident from its continued use in Brazil for a hundred years.

W. J. SHARWOOD.

Homestake Mine  
Lead, S. Dakota

# Western Metallurgical and Chemical Field

## Price Fixing in Zinc, Copper and Aluminium

THE President has approved various agreements entered into between the price-fixing committee of the War Industries Board and interested producers and consumers. Prices on grade A zinc are continued at 12 cents per pound, f.o.b. East St. Louis until Sept. 1, 1918, while 14 cents per pound f.o.b. plant for plate zinc more than  $\frac{1}{8}$  inch thick and 15 cents per pound for sheet zinc subject to the usual trade discounts and extras in effect Feb. 13, 1918, will be the official price until the same date. The expectation of the miners and producers of prime western that a price of 11 cents would be fixed for second grade zinc was thus disappointed.

Following is the specification for spelter for navy requirements, as announced by the Government:

### SLAB ZINC

#### GENERAL SPECIFICATIONS

1. General specifications for inspection of material, issued by the navy department, in effect at date of opening of bids, shall form part of these specifications.

#### GRADES

2. There shall be three grades of spelter, grades A, B and C, respectively, conforming to the requirements stated below.

#### QUALITY

3. "Only virgin spelter, that is, spelter made from ore by a process of direct reduction and distillation, redistillation, electrolysis or a combination of the above shall be furnished in grades A and B. Metal produced by the refining of by-products such as brass mill wastes or other by-products resulting from the manufacture of non-ferrous alloys or similar materials, will not be accepted under Grades A and B."

#### CHEMICAL REQUIREMENTS

4. The chemical properties of the several grades of slab zinc shall be as follows:

#### GRADE A

|                                                           | Per Cent |
|-----------------------------------------------------------|----------|
| Zinc, minimum .....                                       | 99.85    |
| Cadmium, maximum .....                                    | .05      |
| Iron, maximum .....                                       | .03      |
| Lead, maximum .....                                       | .07      |
| Sum of cadmium, iron and lead, maximum .....              | .10      |
| Aluminium, maximum .....                                  | None     |
| Other elements—tin, arsenic, sulphur, antimony, etc. .... | None     |

#### GRADE B

|                                                           | Per Cent |
|-----------------------------------------------------------|----------|
| Zinc, minimum .....                                       | 99.35    |
| Cadmium, maximum .....                                    | .50      |
| Iron, maximum .....                                       | .03      |
| Lead, maximum .....                                       | .20      |
| Sum of the cadmium, iron and lead, maximum .....          | .50      |
| Aluminium maximum .....                                   | None     |
| Other elements—tin, arsenic, sulphur, antimony, etc. .... | Traces   |

#### GRADE C

|                                                           | Per Cent |
|-----------------------------------------------------------|----------|
| Zinc, minimum .....                                       | 98.00    |
| Cadmium, maximum .....                                    | .75      |
| Iron, maximum .....                                       | .08      |
| Lead, maximum .....                                       | 1.00     |
| Sum of cadmium, iron and lead, maximum .....              | 1.50     |
| Aluminium .....                                           | Traces   |
| Other elements—tin, arsenic, sulphur, antimony, etc. .... | Traces   |

The War Industries Board advanced the price of copper to 26c. on July 2. Where contracts for brass tubings, wire, etc., had been made at the 23 $\frac{1}{2}$ c. figure the old prices should prevail until August 15.

A new price for aluminium, effective from June 1 to Sept. 1, 1918, is 33 cents per pound, f.o.b. smelter, 93 to 99 per cent ingot, in lots of 50 tons or over. Differentials for quantity, grade, and alloys remain as before, while differentials for sheets, rods, and wire are increased approximately 12 $\frac{1}{2}$  per cent.

## Work of the Colorado Station of the Bureau of Mines

During the past year at the Bureau of Mines' Experiment Station at the State School of Mines, Golden, Colorado, under the direction of R. B. MOORE, the coöperative work in connection with the National Radium Institute has been completed, and over eight and one-half grams of radium element recovered. The larger part of this radium goes to the officials of the National Radium Institute, who will use it for cancer work. Part of the balance was retained as its share of the work and will be held at the Colorado station for scientific research; a part was presented to the Bureau of Standards, and the rest of it will be at the call of the Army or Navy hospitals. This coöperative work has given the Bureau an excellent opportunity to study the technical and scientific problems connected with the manufacture of radium from carnotite ore.

In addition to carnotite, another uranium mineral, pitchblende, is found in appreciable quantities on Quartz Hill, near Central City, Colo. Two of the mines were formerly owned by Mr. A. I. DuPont, and during his operations a considerable amount of ore was mined and this was ultimately turned over to the Bureau of Mines under a coöperative agreement for experimental purposes. The material was used for a thorough investigation of the best methods of concentration of the low-grade ores and the extraction of radium and uranium. The solubility of radium sulphate in water and in different concentrations of sulphuric acid has been determined, and the results published. This work has a distinct bearing on the precipitation of radium from solutions in plant operations.

The recovery of two other radioactive elements—ionium and actinium—from radium-bearing ores is also being investigated. If these elements could be produced commercially along with radium, they could be substituted for radium in luminous paint, and in other ways. A redetermination of the ratio of radium to uranium in primary uranium minerals will be started shortly. This will have a bearing on the whole question of radium recoveries in the treatment of radium ores, as well as a very definite scientific value.

Many manganese ores carrying silver cannot successfully be treated by cyanidation, the extraction of the silver being altogether too low. Under a coöperative agreement with the Dutch government, a thorough investigation of the treatment of certain of these ores by means of the Caron process is now being carried out. This process involves a preliminary reducing roast, by which the silver extraction can be raised and a satisfactory recovery obtained by cyanidation. It is probable that the scope of this investigation will take up the whole question of leaching manganese ores, and the re-precipitation of the manganese.

Under a coöperative arrangement with the Welsbach Company mesothorium is being investigated, and a

method for the recovery of this element as a by-product in their manufacture of thorium nitrate has been worked out. This mesothorium, which has in the past gone to waste, will ultimately be used for luminous paints for various objects, such as instrument dials, as well as for therapeutic purposes.

The Colorado Station has been particularly interested in molybdenum, and has not only worked on a soluble molybdenum ore from near Ouray, both as regards its composition and treatment, but also has been interested in the concentration and metallurgy of wulfenite and methods of separating molybdenite from copper-bearing minerals. The best conditions for the reduction of tungstic acid to metallic tungsten have been worked out, and results will shortly be published. Work has also recently been started on the metallurgy of certain vanadium minerals, such as vanadinite and cupro-desclowitzite.

### A Tariff or a Bounty on Antimony

The difficulty in imposing a rational tariff on antimony according to the rule—cost of foreign production plus tariff equals American cost—is glimpsed when one understands that the cost of Chinese antimony is unknown except perhaps to the Chinese (and they are not telling), while American mining and smelting are both in such an embryonic condition that even the potential operators do not know what it will cost them on a basis of quantity output. Certain it is that the price of Chinese antimony has fluctuated over such wide ranges in the past years that one suspects speculation by brokers or else market manipulation by those controlling the bulk of the supply. A successful corner in a metal so widespread and so easily won as is antimony, appears to be improbable; on the other hand, more than once in the past 25 years have western miners been enticed by high antimony prices to get small properties to the production stage, then only to find a prohibitively low price.

As is natural at any tariff hearing, many divergent views were expressed by those present at a recent conference with the Tariff Commission in San Francisco. All present (except the importer of Chinese metal) agreed that American antimony could be produced in sufficient quantity at 16 cents; on this basis the miner could receive \$85 a ton for a 50 per cent concentrate, leaving 7½ cents per pound to cover the cost of smelting and selling the metal. This latter item is said actually to cost 5½ to 6 cents at the Los Angeles works of the Western Metals Company. The miner was careful to emphasize, however, that a sufficient tariff wall should be erected against the importation of ore, else by treating cheap foreign ore the smelter would reap all the benefit and the miner none.

The United States' consumption of antimony is moderate. Pre-war requirements amounted to about 7000 tons of metal per year, of which 3000 tons were produced as a byproduct of the refining of antimonial-lead. It is largely used for hardening lead—in the manufacture of bullets, bearing metal and type metal. The present consumption has doubled the demand; it now probably amounts to about 1500 tons per month.

From the facts just indicated, i.e., ignorance of actual production costs, the moderate amount required of this very widespread metal, and its acknowledged impor-

tance in munitions, the tariff commission may with reason recommend that the War Industries Board solve the riddle by offering to purchase for a period of years the munition requirements of American made metal from American ores at a price covering cost plus a reasonable profit. During that time the operations of this industry, then passed from embryonic to the infant stage, can be studied and proper measures taken to insure its continuance.

### Company Reports

**Inspiration Consolidated Copper Company.**—Notwithstanding a strike lasting two months, and a considerably reduced scale of operations for the remainder of the year, Inspiration mined 3,914,742 tons of ores from which 80,566,982 pounds of refined copper was produced, which netted an average price of 26.366 cents. The cost of production, exclusive of depreciation and federal income tax, is tabulated as follows:

|                                                | Cost per lb. | Cost per Ton |
|------------------------------------------------|--------------|--------------|
| Mining.....                                    | 3.572c.      | \$0.7239     |
| Coarse crushing.....                           | 0.163        | .0329        |
| Ore hauling.....                               | 0.101        | .0206        |
| Concentrating and royalty.....                 | 2.951        | .5941        |
| Concentrates hauling.....                      | 0.007        | .0015        |
| Smelting, freight, refining and marketing..... | 3.665        | .6369        |
| Total.....                                     | 10.439c.     | \$2.0099     |

The grade of the ore was purposely dropped to 1.388 per cent copper, containing 0.279 per cent oxide copper, from which 20.39 pounds of copper was recovered. This recovery figures to a little over 75 per cent of all copper, but nearly 90 per cent on the sulphides contained. Important experimental work to increase this recovery was continued, indicating the desirability of retreating sand and slime separately, floating the sulphides from the former followed by a roasting and leaching operation similar to that practiced at Anaconda. The slime, containing a large proportion of the oxides, is to be leached with sulphuric acid. The success of the Ajo plant of the New Cornelia Copper Company treating ores very similar to the 20 million tons of oxides on Inspiration ground seems to settle the question of treatment of these reserves. During the year a new chemical laboratory was constructed at the concentrator, the filter plant was increased 50 per cent, a 200-ft. concrete tank for tailing settlement built, and two additional units added to the mill.

Additional data on the operation of the mill follow:

|                                                                             |      |          |
|-----------------------------------------------------------------------------|------|----------|
| Water Consumption for First Six Months of Year per Ton Ore Milled:          |      | Gal.     |
| Reclaimed in tanks at foot of mill.....                                     |      | 356      |
| Reclaimed in tailings ponds.....                                            |      | 475      |
| New water from Kiser pump station.....                                      |      | 277      |
|                                                                             |      | 1,108    |
| Power Used per Ton Ore Milled for First Six Months of Year:                 |      | Kw.-Hr.  |
| Coarse crushing.....                                                        |      | .43      |
| Fine grinding and concentrating.....                                        |      | 10.87    |
| Blowers for flotation air.....                                              |      | 2.42     |
| Filter and reclaiming water.....                                            |      | 2.01     |
| Lights.....                                                                 |      | .07      |
| Total.....                                                                  |      | 15.80    |
| Steel ball consumption in fine grinding, per ton ore milled (for year)..... |      | 1.82 lb. |
| Flotation Oils per Ton Ore Milled:                                          |      |          |
| Cost tar—lb.....                                                            | 1.21 |          |
| Sundry oils—lb.....                                                         | .11  | 1.32 lb. |

**Phelps Dodge Corporation.**—The concentrator at the Morenci branch treated 312,224 tons of ore containing 2.333 per cent copper, producing concentrates averaging 11.201 per cent copper, and a tailing averaging 0.648 per cent copper, a saving of 71 per cent, on a concentration ratio of 6.78. The metallurgical results here are unsatisfactory owing to inefficient labor, and



irregular and inadequate power, the mill having operated but 54 per cent of the time. An extension to the flotation department is under way, which is designed to increase the savings. Somewhat the same metallurgical conditions obtain at the mill of the Moctezuma Copper Co., where 750,897 tons of ore containing 3.179 per cent copper were treated producing a tailing of 0.747 per cent copper—a saving of 81 per cent. These operations were uninterrupted throughout the year, however, and the net production of 38,186,451 pounds of copper exceeded the previous maximum by over two million pounds of copper. Experimental work is to be continued on the slime, together with other tests to reduce loss in sand-tailing by fine grinding. At the Bunker Hill mines, Tombstone, Arizona, experimental work for the treatment of low-grade gold-silver-lead ores by flotation was unsuccessful owing to high operating costs and poor extraction. Half the mill capacity was used in making manganese dioxide concentrates, which operation produced a silver-bearing tailing suitable for flux. Eleven tons of wulfenite concentrates carrying 2106 pounds of molybdenum were also shipped. Labor troubles in the Bisbee district did not affect the production of the Copper Queen smelter at Douglass, owing to the stocks on hand and the increased shipments from Burro Mountain, Moctezuma, and the United Verde Extension, so that the total output shown below was the largest in its history by a margin of almost 20 million pounds.

|                          | Dry Tons<br>Charged | Ounces<br>Gold | Ounces<br>Silver | Pounds<br>Copper |
|--------------------------|---------------------|----------------|------------------|------------------|
| Copper Queen branch..... | 794,904             | 19,171         | 559,156          | 87,831,317       |
| Burro Mt. branch.....    | 45,868              | 293            | 36,799           | 13,342,508       |
| Moctezuma Copper Co..... | 167,381             | 1,910          | 508,387          | 38,499,781       |
| All other.....           | 268,064             | 10,937         | 946,921          | 31,907,525       |
| Total, 1917.....         | 1,276,817           | 32,331         | 2,042,263        | 191,581,131      |

Offerings of custom ores were more than could be accepted. Minor changes in the various departments are expected to increase substantially the capacity during 1917. The record production of copper was effected with but one fatal accident in the smelting departments.

**Judge Mining and Smelting Co.**—The mill at Park City, Utah, treated 63,387 tons of ore in 501 shifts, producing 11,861 tons of lead concentrates and 5526 tons of zinc concentrates. The electrolytic zinc plant has been continuously and successfully operated since the start, early in the year. The production has been small, however, owing to the impossibility of obtaining desired reagents for the purification of the solutions. This difficulty has been largely eliminated by changes in methods employed, and with a good price fixed for Grade A zinc, production should proceed at the designed capacity.

**Goldfield Consolidated Mines Co.**—The activity of this company is summarized as follows: 250,550 tons of ore was treated, containing \$2,039,103 in metal value, and yielding \$1,762,970; and 81,885 tons of tailings containing \$103,843, of which \$62,326 was recovered. Two-thirds of this production was cyanided, and the balance treated by the flotation process. The latter, operating on low-grade copper ores, has been in continuous service since opening in March. The concentrates are now shipped to custom smelters, since three months' experience with a local concentrate-treatment plant proved unsatisfactory, and tests indicated that they cannot profit-

ably be cyanided without a chloridizing roast. The company has opened a store for the purpose of reducing the cost of living, with pronounced success and unqualified approval from the employees. All business is conducted on a cash basis, and a preferential discount of 10 per cent given to employees. The cost of operation including the discount is 19 per cent. of the total sales, and the department sustained a loss of \$4000 in ten months' operation. The appended tabulation shows very graphically the trend of the company's operations, and about the middle of the year it became apparent that the ore exposed would not yield a profit. Later development work is distinctly encouraging, however. Nevertheless a statement of recoverable assets and the scrap value of the equipment after operations have ceased includes the following items:

|                             |             |
|-----------------------------|-------------|
| Scrap value of plant.....   | \$250,000   |
| Mill clean-up.....          | 100,000     |
| Profit from subsidiary..... | 300,000     |
| Profit from mine.....       | 200,000     |
| Profit from tailings.....   | 500,000     |
| Supplies and stores.....    | 330,000     |
| Cash and investments.....   | 551,000     |
| Total.....                  | \$2,431,000 |

which could be realized during a period of about six years. The following comparative data are interesting:

|                                   | Average<br>Recovery | Average<br>Cost | Net     |
|-----------------------------------|---------------------|-----------------|---------|
| Year ending Oct. 31, 1909.....    | \$34.72             | \$8.88          | \$25.84 |
| Year ending Oct. 31, 1910.....    | 38.50               | 10.97           | 27.53   |
| Year ending Oct. 31, 1911.....    | 30.74               | 7.97            | 22.77   |
| 14 mos. ending Dec. 31, 1912..... | 18.40               | 6.65            | 11.75   |
| Year ending Dec. 31, 1913.....    | 14.14               | 6.32            | 7.82    |
| Year ending Dec. 31, 1914.....    | 11.61               | 6.19            | 5.42    |
| Year ending Dec. 31, 1915.....    | 9.01                | 5.02            | 3.99    |
| Year ending Dec. 31, 1916.....    | 6.53                | 5.18            | 1.34    |
| Year ending Dec. 31, 1917.....    | 7.64                | 6.01            | .68     |

**The Consolidated Mining and Smelting Company of Canada, Ltd.**—Reminders of the recent acute state of the Canadian lead market are contained in the report of this company, operating the Trail smelter, showing a large bank overdraft (\$2,081,806.24) which the president of the company, MR. W. D. MATTHEWS, states is due to the unusual accumulation of ores in anticipation of the needs of the Imperial Munitions Board. Overbalancing this is metalliferous material valued at \$2,615,664.17, subdivided as follows: Pig lead on hand and in transit to refineries, \$29,242.95; ores on hand, \$1,502,698.20; refinery metals on hand, \$1,014,819.10, and ore in transit to smelter, \$68,903.92. The last year has been one of extraordinarily diversified activities at the smelter, the construction ending Sept. 30, 1917, totalling \$1,442,883.12. The electrolytic zinc plant was completed, and a daily production of over 60 tons of pure zinc reached, while a 400-ton concentrator was erected to treat the Sullivan ores. In the lead plant the new bedding system was completed, and a record production of 22,133 tons metal attained with the best metallurgical results in recent years. The sulphuric acid plant was doubled in capacity, and now produces thirty tons of chamber acid per day. After supplying the entire needs of the refineries and the zinc plant, there is a surplus for commercial sale. The hydro-fluosilic acid plant produced 196 tons of 100 per cent acid, providing the entire requirements of the lead refinery. Two new retorts are now under construction, to double the capacity of this plant. Taking these departments into consideration, the Trail plant is producing on a commercial scale bluestone, sulphuric acid, hydro-fluosilic acid, gold, silver, copper, lead and zinc.

## The President's Readjustment and Reconstruction Commission—III

BY WINGROVE BATHON

Washington Correspondent, McGraw-Hill Co., Inc.

**F**OLLOWING the presentation in McGraw-Hill Engineering Publications of a concrete plan for a proposed Readjustment and Reconstruction Commission to be appointed *now* by the President of the United States, to deal *now* with problems which will be presented to American Industry after the war, it has become known in Washington administrative circles, in an unofficial manner, that a plan for a readjustment and reconstruction agency is under consideration.

### COUNCIL OF NATIONAL DEFENSE STUDYING PROBLEM

It is permitted to say here publicly for the first time that the Council of National Defense has been studying the subject of readjustment and reconstruction for a lengthy period, with a view to co-ordinating various Government activities in Washington which have had readjustment and reconstruction for their object. When President Wilson recently set up the War Industries Board, under the chairmanship of Mr. Bernard M. Baruch, as a separate agency, divorcing it from the Council of National Defense, the latter organization was left with but little work to do, and with but few prominent men remaining in its personnel. There is reason for the belief that the Council of National Defense has resolved to undertake the work of readjustment and reconstruction, if permitted to do so by President Wilson, and there is also reason for the belief that the President will assent, under the urging of Secretary Baker of the War Department, chairman of the Council, acting in behalf of himself and the other five members of President Wilson's cabinet who compose the Council of National Defense.

In Washington official circles there is an impression that this would be a logical step, inasmuch as a number of cabinet officials have begun making public details of readjustment and reconstruction ideals upon which their own departments and bureaus have been separately at work, following the advocacy of such a readjustment and reconstruction agency in McGraw-Hill Engineering Publications. There is ground also in Washington not only for the impression but for the strong belief that if the Council of National Defense is authorized by the President to begin work on readjustment and reconstruction problems, W. S. Gifford, Director of the Council, will not only set to work at once to co-ordinate all the work being separately done in the various departments but will undoubtedly call into consultation and activity at Washington men in private industry of the type suggested in the first article in this series which was put forth as a method of crystallizing opinion in favor of a readjustment and reconstruction agency and obtaining action to create one. In other words, it is in expectation in Washington that, if the President assents, the Council of National Defense will be newly created by the appointment of a large number of committees of important men of the type suggested in the first article in this series, taken from the ranks of private endeavor, to solve now the after-the-war industrial problems of this country, as England is now doing.

Before this is published, the question of what char-

acter of readjustment and reconstruction agency shall be established may have been settled. It is possible that when the announcement of the Government's intentions in this respect is made, it will have been found after due consideration that it might be more wise to commit the work of readjustment and reconstruction to an agency other than the Council of National Defense; but the subject is now being discussed on all sides in Washington, and letters and telegrams from all over the country are being received in Washington urging the creation of such an agency at once.

From Philip H. Gadsden, chairman of the National Committee on Public Utility Conditions, comes a letter strongly indorsing the idea of action. The National Committee on Public Utility Conditions, which includes E. K. Hall, H. H. Crowell and A. S. Hills, executive secretary, represents in Washington the National Electric Light Association, the American Electric Railway Association, the American Gas Institute, and the National Commercial Gas Association. Mr. Gadsden says:

"It is coming, I think, to be more and more generally realized that the problems which the industrial world will have to face after the war in the readjustment of our economic life will be more serious than even the problems which we are now called upon to meet. Your suggestion, therefore, that the President at this time appoint a Commission on Readjustment and Reconstruction, in my judgment, is a very timely one.

"The great lesson which this war has impressed upon every one is the efficiency resulting from great concentration of capital and labor. The benefits derived by the nation for war purposes in the mobilization of practically all the industries of the country will not be lost sight of when peace comes. To deal properly with such a radical change in our economic policy will call for all the wisdom at our command. Nothing could aid so much in the proper solution of such a problem as a thorough and comprehensive study of it in advance, such as you suggest."

From the Permutit Company, engaged in water rectification and general sanitation, New York, comes this letter, signed by Samuel Robert, President of the Company:

"As we see it, there can hardly be room for doubt as to both the usefulness, and, indeed, the necessity, for the work of the nature referred to, and that this work should be done as quickly and as thoroughly as possible.

"We can think of no better way to prepare the ground work essential to the proper accomplishment of this vital project (vital to the future benefit of the industries of this great country) than by having a commission appointed as quickly as possible for the express purpose of investigating the necessary steps needed to prepare for its accomplishment, and then to put into effect as thoroughly as possible the means needed for its fulfillment. We are in hearty accord with this movement."

### DEMANDS OF RECONSTRUCTION PERIOD NOT APPRECIATED

From Charles F. Lang, President of the Lakewood Engineering Company, Cleveland, Ohio, comes this letter:

"While our company is working night and day on war service for the Government, and is constantly endeavoring to expand its usefulness in this direction, all our planning is being done with a view to world-trade conditions after the war, for we feel that we but dimly realize the demands which world-trade will make upon American manufacturers in the reconstruction-period immediately following the war.

"And we also recognize the period of tremendous readjustment which must take place in our own country. National conditions and national ideals are entering a violent revolution rather than a slow evolution, and I sincerely trust that the very constructive program suggested by you will receive serious consideration and prompt action on the part of the Government; for the



problems involved are not merely national, but world problems; and individual thinking by individual business men is hopeless—the nation must think and plan *as a Nation.*"

From the great merchandising house of William Filene Sons Company, Boston, Mass., comes this letter, signed by Edward A. Filene, its President, who is Chairman of the War Shipping Committee of the Chamber of Commerce of the United States:

"I am in entire agreement with your suggestion that such preparation should be under way. Unless there is created a Governmental Agency for this undertaking, an agency thoroughly representative of all classes and interests, these problems will be taken up separately by the various classes and interests."

#### UNITY OF PURPOSE VITAL TO WELFARE OF COUNTRY

"If the bulk of the reconstruction planning is left to separate classes and interests, we shall come to the end of the war with a series of reconstruction programs. Business will have a program; labor will have a program; agricultural interests will have a program; banking interests will have a program; socialists and holders of relating theories will have a program. And, at the very moment when unity of purpose and promptness of action will be vital to the welfare of the country, we shall be obliged to pay the price of costly delay incident to the harmonizing of these several programs of reconstruction.

"It is clearly the wise policy to create a government commission so thoroughly representative of all classes and interests that it will command the support of all classes and interests. If such a commission collates its facts, formulates its conclusions, and submits them in advance to the most exhaustive criticism from all possible angles, we shall be able to get most of the work of compromise out of the way by the end of the war and arrive at the time of action with a unity of purpose and policy otherwise impossible.

"I realize the question of tactics and timeliness involved in any proposal today not related to the immediate job of prosecuting the war; and yet, the war will end some day, and whether that time be one year or twenty years from now, the time will be none too long for the analysis of the complicated problems that underlie the return of our social, industrial, and political life from a war basis."

#### Fourth National Exposition of Chemical Industries

THE Fourth National Exposition of Chemical Industries will be held in the Grand Central Palace, New York, during the week of Sept. 23 this year. The advisory committee is composed of Charles H. Herty, chairman; Raymond F. Bacon, L. H. Baekeland, Elwood Hendrick, Henry B. Faber, Bernard C. Heese, A. D. Little, Wm. H. Nichols, R. P. Perry, H. C. Parmelee, G. W. Thompson, F. J. Tone, T. B. Wagner and M. C. Whitaker. Dr. Bacon of this committee is now head of the Chemical Warfare Section of the National Army and a member of General Pershing's staff.

The coming exposition will be the largest chemical exposition ever held and it will be necessary to use four floors of the Grand Central Palace. Regarding the exposition as a war-time necessity, each exhibitor is planning an exhibit that will be of the greatest benefit to the country through the men who visit it, all of whom are bent upon a serious purpose—that of producing war materials in large quantities, and constantly increasing this production till the war has been won by the United States and its Allies.

The amount of floor space already engaged is greater than last year; the exhibits will be much more attractive and a movement is under way to show all exhibits of machinery in operation under actual working conditions

as they would be found in the field. The products of chemical manufacturing as they enter into the world's commerce will be shown as examples of what the chemist has produced in America since the world war began.

The South is again sending exhibits from some sections, and Canada, too, is taking the opportunity of presenting the materials it has available for development by the chemist and financier. Technical and business men over the country give heed to these exhibits since they will show how they can meet the war-time need. A section for the glass and ceramic industry has been added with which the American Ceramic Society is co-operating.

The program for the exposition is in active preparation and will be a series of symposia on the "Development of Chemical Industries in the United States, notably since July, 1914." This will embrace the period since the beginning of the European war, which by removing the source of supply for some of our domestic industries has inspired the development of our own chemical industry. The program of motion pictures carries forward the idea of the symposia.

#### War Industries Board Plans Conservation of Tin

THE plan upon which the War Industries Board is working for the conservation of tin is based on the conviction that no government official, department or bureau can be in position to apply restrictions to industries as wisely as the men who have spent their lives in the industries affected and are thoroughly acquainted with the technical details and the business consequences involved.

The Board calls meetings of representatives of each important trade using tin, states the necessity for economy, asks for patriotic coöperation and seeks advice as to how to get the results desired. Each industry is asked to organize, to consider the problem and submit specific recommendations. These recommendations are digested and sent to everyone in each trade concerned. Conferences are held with those who may not agree with the recommendations so as to get as complete unanimity as possible. A set of recommendations or regulations is then drawn up for each industry and these are enforced by the authority of the War Industries Board.

The various uses of tin by different trades are classified in an ascending scale of importance.

*First:* Wasteful uses due to carelessness, ignorance or indifference. Wastes due to faulty practice which might be cut off not only without injury to anybody but rather to the definite pecuniary advantage of manufacturers.

*Second:* Uses non-essential in character, such as the coating of articles with tin for ornamental purposes solely. Uses which could be cut off without injury to any individual or firm, provided all acted alike.

*Third:* The employment of tin for purposes which in themselves are useful and desirable, so that their elimination would involve a certain amount of sacrifice on the part of manufacturers or consumers; but which are in no way connected with the vital needs of the country in relation to the war.

*Fourth:* Uses directly for war purposes either by the



Government itself as a manufacturer of war materials or by manufacturers who are making war materials for the Government.

Uses under "first" and "second" can and should be cut off at once. Under "third" curtailment is not in itself desirable. It will result in a certain disorganization of industry and reduction in economic efficiency and ought to be avoided if possible. But the sacrifice will probably have to be made. Lastly, come the direct war requirements, which must be met in full or military efficiency will suffer.

The following results have already been accomplished:

### 1. SOLDER AND BEARING-METALS

*Standardizing.* There are scores of compositions used in bearings-metals and solder. The Bureau of Standards has completed an investigation of bearing metals and has suggested elimination of all but four grades. This recommendation was adopted by the meeting and it is stated that a saving of about 25 per cent in amount of tin will be effected. The Bureau of Standards is making similar investigations concerning solder. The can companies have reduced the percentage of tin in their solder to forty, thus saving from 8 per cent to 10 per cent without injury to the industry.

### 2. BRASS AND BRONZE INGOTS AND CASTINGS

Most of this business is directly or indirectly for Government account. Considerable reduction could be made in tin content without reduction of efficiency. Large savings have already been made by automobile and other machine manufacturers by substituting for all metal bearings, case bearings with thin lining shell ( $\frac{1}{16}$  in. to  $\frac{1}{8}$  in.) of high-grade babbitt. Straits tin is often specified on the assumption that it is the purest tin. Banca is even purer than Straits or Australian, and electrolytic tin is as pure.

Manufacturers of tinfoil and collapsible tin tubes have effected large savings by reducing the tin content, and by substitution of other materials for containers. A plan was suggested and is now being perfected for the recovery of a large part of the tin used in foil and tubes. Through a campaign of advertising, through notices on the packages, and other methods, consumers of articles packed in foil or tubes will be induced to save these articles and turn them in at the nearest Red Cross center as donations. Smelters and other users of tin will then purchase at market rates the lots thus collected by the Red Cross. It is estimated that this will recover some 3000 to 5000 tons of tin per annum, and bring the Red Cross an added income of from \$4,000,000 to \$5,000,000.

### 3. TIN PLATE

Plans for the conservation of tin plate have long been in the hands of the Committee on the Conservation of Tin Plate. In coöperation with the trades concerned large economies have already been effected. The manufacture of plate for many less-essential uses, such as roofing, for store boards, for fire doors, etc., has been eliminated by agreement. Tobacco manufacturers have just reached an agreement by which black plate will be substituted for tin plate for most tobacco cans, effecting a saving of probably 750,000 base boxes of tin plate per annum. In addition, the

quantity of plate required for export has been greatly curtailed by the regulations for the War Trade Board restricting export to plate which is to be used for specific war purposes.

## Post-War Problems of the Electrochemical Industry

The American Electrochemical Society will hold its Fall meeting at Princeton, N. J., Sept. 29 to Oct. 1, and is planning to devote one session to a consideration of the reconstruction and post-war problems of the industry. The status of all our industries after the war is a most important question and deserves careful study at this time. This is especially true of many electrochemical industries which the demands of the war have stimulated to a point of expansion far beyond the requirements of peace.

Many of these industries such as the chlorine and alkali industry, the ferro-alloy industry, the manufacture of electric steel and the carbide industry have undergone an enormous expansion. We shall have the problem of the disposition of Government-owned plants. We must develop new uses in the arts of peace for the products of our war plants. Most all of these questions of reconstruction and readjustments are pressing in view of the world-wide competition which will follow a declaration of peace. Other subjects are the future of air nitrates, the electric power situation and research after the war in its varied university, Governmental and industrial phases.

A topic of far-reaching importance is the future relations of technical men to the affairs of Government. Can the very important work of some of our technical boards be continued after the war and made to function with the administrative and legislative branches of the Government?

## How Great Britain is Handling Post-War Questions

The British Ministry of Reconstruction has just published a complete list of the various commissions and committees that have been set up, both within that ministry and within other ministries and departments of the British Government, to deal with questions which will arise at the close of the war. These commissions and committees, which have been appointed at different times since the war began, now number 87 and fall into 15 groups of which the following will be of interest to the metallurgical and chemical industries:

To create a committee representative of the chemical trades for the development of its own resources and the securing of co-operation of all engaged therein.

To consider the international competition to be expected in the metallurgical industries, and devise proper safeguards required to maintain their position.

To investigate various processes for nitrogen fixation, survey the raw materials required, investigate the production of cheap power, to carry out preliminary experimental work, and to advise as to proper conservation of nitrogenous compounds.

To consider carbonization of industrial and domestic fuel.

To institute research on the preparation and utilization of fuels.

To advise on research in metallurgy and glass making.

To investigate the preparation, properties and applications of abrasive and polishing powders.

To prepare a reference list of the composition, densities, and optical characteristics of vitreous compounds and cements for same.

To control researches in tin and tungsten.

To survey the lubrication field, institute research on problems involved, and to collect and review the chemistry of lubricants and oils.

To collect and review existing information on copper and zinc manufacture as a basis for future research, and to institute research into methods of making sound castings and brass tubing.

To formulate methods of improving permanently the relations between workmen and employers.

To advise as to the opportunities of post-war employment of women.

## Federal Supervision of Niagara Falls Power

AS announced in this journal, Dec. 1, 1917, the War Department took over the supervision of the supply of electrical power at Niagara Falls in November, under the immediate direction of Robert J. Bulkley and Brig. Gen. Charles Keller. The first result of the supervision was to requisition for the United States all power generated or imported by the Hydraulic Power Company and the Niagara Falls Power Company, both of Niagara Falls, New York, and distribute it to war industries. The War Department now announces that as a result of this supervision accurate knowledge has been obtained of the use of power generated in this country in the Niagara Falls district and that imported from Canada. This information shows that practically all the power available is used to aid the prosecution of the war, direct war industries securing an average of 85.29 per cent of the total power of the two requisitioned companies and an average of 54.29 per cent of the total power of the cooperating companies. Under war conditions the power supply falls short of the demand by about 200,000 horsepower, which amount is not based on new industries but is determined as the amount of power which could be absorbed by the industries now operating, were such a supply available.

Some of this shortage will be relieved by the proposed enlargements of the steam plants of the Buffalo General Electric Co., and the Niagara, Lockport & Ontario Co. Additions to these two plants will aggregate 62,000 horsepower. By means of a further development by the American hydro-power companies at Niagara Falls their existing supply of power, amounting to about 250,000 horsepower, will be increased by about 160,000 horsepower. Many prominent men believe that the total available water power should be put to use.

The increased allotments of power to the essential electrochemical industries in the Niagara district and to the plants devoted to the production of such essentials as ferrosilicon, electrodes, phosphorus, chlorine and abrasives have conclusively demonstrated the beneficial results of regulating and controlling the distribution of power.

## Governmental Control of Sulphur-Bearing Materials

THE War Industries Board has decided to take control of the production and allocation of sulphur, pyrites and coal brasses and has authorized Mr. William G. Woolfolk, commodity chief in charge of pyrites and sulphur, to act for the Board in controlling the production and distribution of sulphur materials.

It has been apparent for some time that the increasing consumption of sulphur-bearing materials would soon necessitate action looking toward the conservation of existing supplies and development of new sources. With this end in view the War Industries Board on May 29 requested the Chemical Alliance, Inc., to submit a plan covering the allocation of sulphur-bearing materials. The directors of the Alliance met on June 7 and decided to submit a plan. At the same time they invited the producers and consumers of sulphur-bearing materials to meet with them and approve or disapprove the plan. On June 11 the directors of the Chemical Alliance recommended the appointment of a committee to consist of three directors of the Alliance and a representative of the War Industries Board which should have charge of sulphur distribution. It appears that after receiving this report the War Industries Board decided to assume control for the Government. Mr. Woolfolk acting for the Board will avail himself of the assistance of the committee which the Alliance constituted at its meeting on June 7, which will probably comprise Messrs. A. D. Ledoux, W. D. Huntington and C. G. Wilson. Under the by-laws of the Alliance the president and vice-president act as *ex-officio* members of all committees. The committee will be known as the Committee on Production, Distribution, Control of Sulphur Materials.

## Classification of Productive Occupations by War Department

In the regulations announced by Provost Marshal General Crowder affecting all men of draft age it will be of interest to chemists and metallurgists to note the following occupations which are indicated as productive:

|                             |                     |
|-----------------------------|---------------------|
| Chemical engineer.          | Digger (mucker),    |
| Chemist or chemical worker: | Drill runner,       |
| Acids and dyes,             | Laborer,            |
| Analytical,                 | Mine foreman,       |
| Explosives,                 | Miner,              |
| Fireworks,                  | Powderman,          |
| General,                    | Quarry foreman,     |
| Inorganic,                  | Quarryman,          |
| Metallurgical,              | Timberman,          |
| Organic,                    | Topman,             |
| Poisonous gases.            | Track layer.        |
| Foundryman:                 | Mining engineer.    |
| Core maker,                 | Rubber worker:      |
| Cupola tender (melter),     | Bootmaker,          |
| Furnace and ladleman,       | General,            |
| Molder.                     | Tire repairer,      |
| Gas maker:                  | Vulcanizer.         |
| Acetylene,                  | Sheet-metal worker: |
| Hydrogen, oxygen,           | Coppersmith,        |
| Illuminating gas,           | Lead burner,        |
| Poisonous gas,              | Solderer,           |
| Metal finisher:             | Tinsmith,           |
| Brass,                      | Any other.          |
| Nickelplater,               | Welder (cutter):    |
| Niterbluer,                 | Aluminum welder,    |
| Polisher.                   | Autogenous or oxy-  |
| Millwright.                 | acetylene,          |
| Miner or quarryman:         | Electric,           |
| Blastor,                    | Flue welder,        |
| Crusher operator,           | Thermit welder,     |
| Demolition man,             | Any other.          |

## Price-Bidding in War Times

A Discussion of the Economic Principles Involved in Public Control of Industry Versus Unrestricted Competition—Effects of Price-Bidding on Labor and Production—Experience of Great Britain

By ROSWELL C. MCCREA

THE following quotations represent fairly well the prevailing economic philosophy of business men:

"The business of life is better performed when those who have an immediate interest in it are left to take their own course, uncontrolled either by the mandate of the law or by the meddling of any public functionary. The persons or some of the persons, who do the work, are likely to be better judges than the government of the means of attaining the particular end at which they aim . . . the individual agents have so much stronger and more direct an interest in the result, that the means are far more likely to be improved and perfected if left to their uncontrolled choice."

"*Laissez faire*, in short, should be the general practice; every departure from it, unless required by some great good, is a certain evil." (John Stuart Mill: *Political Economy*.)

"A market price . . . is a price fixed by the self-interest of buyers and sellers, each acting independently—that is, with *free competition* on both sides. The price thus fixed is generally an advantageous one for society. . . . If buyers are allowed to compete and force prices up at the very beginning of a scarcity, the advancing price at once operates as a warning to use the article economically. This of itself causes the article to hold out longer. It will also generally happen that the advancing prices lead the producers to send more goods to the market where higher prices prevail; and that long before the advent of actual famine new sources of supply are developed, by which the severest scarcity is avoided. If this result can be secured by a moderate advance in price, it is worth many times what it costs. For it must be remembered that high prices are not so much an evil in themselves, as an indication of an evil. If they exist in an open market, it shows that certain needs of the community are adequately supplied. It often happens that the higher prices serve as a natural cure for the underlying evil, and that the effort to force those prices down by custom or law prevents the evil from curing itself. If custom or law prevents buyers from paying a competitive price, it soon means that some buyers must go without things they very much want." (A. T. Hadley: *Economics*.)

This philosophy has recently come vigorously to the fore as a conclusive rejoinder to those who would safeguard public interests by regulating consumption, restricting competition and fixing price standards. Its basal assumption is that falling prices lead to reduced production. It has grown out of the observation of the proximate effects of price changes in a limited market, and takes little account of the causes and effects of changes in industrial technique or the underlying causes of productive efficiency. It posits a freely competitive organization, operating with mobile capital and labor units of constant efficiency, in which the profit incentive of rising prices stimulates the energies of producers already in the field and speedily draws into the competitive arena a host of new profit-seeking adventurers. The effect of this wholesome tendency is depicted as making for price-levels in which marginal costs are determinative and basal.

### OBJECTIONS TO PRESENT ACCEPTANCE OF DOCTRINE

A fundamental objection to the acceptance of this point of view for present purposes is that freely competitive conditions do not exist and that production

units are neither freely mobile nor constant in efficiency. The psychology of those whose capital or whose energies are thrown into production is a variable quantity, the functioning of which varies in degree with industrial and social conditions. Price changes are merely one set of these conditions and their influence may easily be overestimated.

A dominant characteristic of modern industry is its large degree of use of capital goods in highly specialized, fixed forms. The old economist reasoned in terms of the corner grocery store with its easily fluctuating stocks of goods, which could be built up or depleted in a week. The typical modern establishment is the railroad or mine or factory. Its organization cannot be built up in a day. This requires months, often years, of planning and of preliminary production. Once established, its destiny is largely fixed. Its range of alternative uses is narrow. This condition has a marked influence on the flow of capital into new channels of utilization. The man of small capital or of undemonstrated capacity is ruled out by the size of the stake he must lay to get into the game, and the man of tried capacity and large command over resources will transform the wealth he may control into fixed forms only on the assurance of a reasonable profit margin and of a market of measurable permanency. A steady flow of profits is the lure, and certainty in price may be more of a stimulus to extensions and improvements than fortuitously rising prices.

### FAVORED PRODUCERS PROFIT BY PRICE-BIDDING

As a fact, profits are quite as likely to result from lowered production costs, due to rising productive efficiency, as from rising price-levels. The latter may draw the productive margin to a lower level; but this may well be at the expense of possible output, if there is no accompanying improvement in methods of exploitation. The more advantageously situated production units will reap larger profits through an altered distributive alignment; but no appreciable augmenting of production is likely to result. Favored producers would be quite inclined by prevailing methods to make hay while the sun shines, while those on the margin who hesitate to make new fixed capital outlays would continue to hesitate. *Laissez faire* means hesitancy, and price-bidding means the swelling of the purses of more advantageously situated producers, without any corresponding increase of gross product. An established price, affording certainty for a reasonable period, would be much more likely to swell production. It would encourage the hesitant and by establishing a price norm would afford an incentive-laden standard by which to measure the effects of improvements in productive processes.

I have urged these considerations in hypothetical form. There are many historical, as well as contem-



poraneous illustrations of their truth. Permanent and substantial increases in the production of goods have come not from competitive price-bidding, but in consequence of the application of the fruits of experimental knowledge. Antecedent to every increase of production, changes in productive processes have occurred, and to these the augmented product should be credited. Increased production leads to falling prices. The former stands to the latter in the relation of cause and effect; rising prices and perennially growing production are not thus related. A seemingly paradoxical corollary of this thesis is that large fortunes have sprung from new products or new methods that have led to lowered prices rather than from increased prices accompanying stabilized production methods. The latter situation, where irremediable or unimprovable, has usually led to substitutions. We make a mistake in emphasizing fixed rather than variable conditions in economic reasoning. A current illustration is the food situation in Central Europe. Under the pressure of war, Germany did not trust to rising price-levels to assure her an

cheapness and plenty to the consumer. We can double the present agricultural output but only by methods which reduce its price."

#### HIGH PRICES VERSUS IMPROVED METHODS OF ORE TREATMENT

The same conclusion holds in the exploitation of underground resources. The uninitiated are apt to think of ore beds as of even composition, varying in thickness and in degree of advantage of location. Gradations of price are pictured, corresponding to the varying costs of exploitation of different beds. It is, of course, obvious that for the most part minerals are of uneven composition. At a given time the major portion of existing deposits may well be of too low grade to be worked at a profit. Rising prices make good mines more profitable, but do little to make the production of low-grade ores either abundant or profitable.

Low-grade ores come into use through new methods of extraction. The prodigious expansion of the steel industry has come, not because of increased prices of

TABLE I.

| Commodity                           | Amount Produced 1911 | Total Value   | Amount Produced 1914 | Total Value   | Amount Produced 1916 | Total Value     | Amount Produced 1917 | Total Value     |
|-------------------------------------|----------------------|---------------|----------------------|---------------|----------------------|-----------------|----------------------|-----------------|
| Wheat (bu.)                         | 621,358,000          | \$543,063,000 | 891,017,000          | \$878,680,000 | 636,318,000          | \$1,019,968,000 | 650,828,000          | \$1,307,418,000 |
| Corn (bu.)                          | 2,531,488,000        | 1,565,268,000 | 2,672,804,000        | 1,722,070,000 | 2,566,927,000        | 2,280,729,000   | 3,159,494,000        | 4,053,672,000   |
| Oats (bu.)                          | 922,298,000          | 414,663,000   | 1,141,060,000        | 499,431,000   | 1,251,837,000        | 555,928,000     | 1,587,286,000        | 1,061,427,000   |
| Rye (bu.)                           | 33,119,000           | 27,557,000    | 42,779,000           | 37,018,000    | 48,862,000           | 59,676,000      | 60,145,000           | 100,025,000     |
| Barley (bu.)                        | 160,240,000          | 139,182,000   | 194,955,000          | 105,905,000   | 182,309,000          | 160,646,000     | 208,975,000          | 237,559,000     |
| Potatoes, white (bu.)               | 292,737,000          | 233,778,000   | 409,221,000          | 199,460,000   | 286,953,000          | 419,333,000     | 442,536,000          | 545,865,000     |
| Rice (bu.)                          | 22,934,000           | 18,274,000    | 23,649,000           | 21,849,000    | 41,325,000           | 36,673,000      | 36,278,000           | 68,717,000      |
| Sugar (short tons)                  | 960,374              | 102,664,000   | 968,674              | 91,500,940    | 1,133,626            | 156,009,600     | 1,094,240            | 167,703,220     |
| Sheep and mutton (b.)               | 760,528,000          | 85,179,136    | 654,262,000          | 89,633,894    | 607,473,000          | 97,803,153      | 575,733,000          | 123,782,595     |
| Cattle and beef (lb.)               | 6,594,011,000        | 637,393,078   | 6,632,464,000        | 908,717,712   | 7,276,155,000        | 1,004,109,390   | 8,611,217,000        | 1,463,906,890   |
| Hogs and pork (lb.)                 | 7,953,168,000        | 962,333,328   | 8,319,048,000        | 1,281,133,392 | 10,578,274,000       | 1,703,102,114   | 8,473,899,000        | 2,059,157,457   |
| Bales of cotton                     | 15,553,073           | 749,890,000   | 15,905,840           | 591,130,000   | 11,363,915           | 994,060,000     | 11,000,000           | 1,517,558,000   |
| Raw wool                            | 331,547,900          | 52,716,116    | 346,192,000          | 60,929,722    | 300,890,000          | 83,045,640      | 298,573,000          | 140,926,456     |
| Iron ore                            | 40,989,508           | 86,419,830    | 39,714,280           | 71,905,079    | 77,870,553           | 181,902,277     | 75,649,000           | 236,178,000     |
| Copper ore                          | 29,988,235           | 137,154,092   | 35,175,541           | 152,968,246   | 57,667,241           | 474,288,000     | 55,600,000           | 510,300,000     |
| Pig iron                            | 23,257,288           | 327,334,624   | 22,263,263           | 298,777,429   | 39,126,324           | 663,478,118     | 38,157,897           | 1,111,500,000   |
| Steel rails (number)                | 2,823,000            | 79,044,000    | 1,945,000            | 54,460,000    | 2,855,000            | 91,360,000      | 2,925,000            | 99,267,000      |
| Locomotives built (number)          | 2,915                | 32,002,939    | 1,485                | 25,768,078    | 2,880                | 57,202,146      | 3,076                | 25,072,294      |
| Freight cars (number)               | 64,810               | 59,708,199    | 95,253               | 92,123,511    | 118,016              | 132,559,842     | 123,538              | 206,100,974     |
| Passenger train cars (number)       | 3,499                | 42,837,111    | 3,623                | 43,245,589    | 1,338                | 17,001,885      | 1,621                | 25,072,294      |
| Interurban and subway cars (number) | 557                  | 3,417,574     | 304                  | 1,660,117     | 552                  | 2,113,520       | 426                  | 3,599,971       |
| Street railway cars (number)        | 3,014                | 9,120,352     | 2,101                | 5,406,444     | 1,237                | 4,048,695       | 1,140                | 3,984,502       |

adequate supply of grain. She turned to a cheaper substitute. But for the potato Germany would before this have been starved into submission. Many of the productive potato lands were barren soil a century ago. Scientific experimentation adapted the potato to these waste regions, supplemented by soil analysis which afforded knowledge of added elements requisite for potato cultivation. Beyond the limits of any possible increase of production through the bidding up of prices, is an immeasurably larger permanent increase of gross product resulting from better application of skill and knowledge to local conditions.

#### HIGH PRICES FAIL TO STIMULATE PRODUCTION

"The production of sheep and wool in England was stationary until improvements in food and in breeding were wrought. It was the turnip and the new breeds of sheep which increased production of wool and not its high market price. The changes in cattle breeding both in regard to milk and beef tell the same story. The growth of these industries is a history of improved methods, each great change in the quantity produced being the consequence of antecedent stock improvements. These lessons America must take to heart if a remedy for our food shortage is to be found. High prices of food products will fail to stimulate an increase of their production. The remedy is in improved methods of production bringing prosperity to the farmer but also

pig iron, but through new processes of extracting ores and new economies of manufacture. The increase in the production of silver is a good example of the same tendency. The output of silver remained stable for centuries, little affected by prevailing high prices. What high prices could not do was accomplished by advancing chemical art. Increased production at lower prices followed.

"The history of every mineral product tells the same story. Stationary production is the accompaniment of high prices. We get increased production not in this way but by discovery, invention and increased knowledge, making the growth a result of these causes and not of price bidding. High prices is a distributive process creating profits, not a productive process augmenting production. Only when this is seen can an epoch of high prices like the present be understood. The urgency of war leads to vain attempts to speed up production. From them come high prices and inflation, but gross production is more often decreased than increased thereby."

A current experience of some illustrative value in this connection is brought out by figures published in the annual report to stockholders of the United States

<sup>1</sup>From a paper on "The Fallacy of Price Bidding" read by S. N. Patten at the recent annual meeting of the American Academy of Political Science. This important paper will appear in the July number of the *Annals of the Academy*.

<sup>2</sup>Patten, *supra* cit.

Steel Corporation for 1917. There is a falling off in tonnage of approximately 5 per cent.

|                                | 1917        | 1918        |
|--------------------------------|-------------|-------------|
| Iron ore mined .....           | 31,781,769  | 33,355,169  |
| Limestone quarried .....       | 6,494,917   | 7,023,474   |
| Coal mined .....               | 31,496,823  | 32,768,381  |
| Coke manufactured .....        | 17,461,675  | 18,901,962  |
| Blast furnace production ..... | 15,652,928  | 17,607,637  |
| Steel ingot production .....   | 20,285,061  | 20,910,589  |
| Rolled steel products .....    | 14,942,911  | 15,460,792  |
| Total .....                    | 138,116,084 | 146,028,004 |

The lack of correspondence between rising market values and volume of product is well illustrated by Table I. In the case of agricultural products, fortuitous and incalculable elements, such as varying weather conditions, have had an important effect. But the figures still have appreciable value.

#### THE ENDLESS CHAIN IN PRICE-BIDDING

A significant cause of the failure of price-bidding inflation to yield corresponding expansion in gross product lies in the fact that the bidding up tendency speedily extends to labor and intermediate goods which are in turn the products of labor. The wished-for harvest is great; and laborers are few. Immigration has virtually ceased. Our labor supply has become a fixed quantity and as successive military drafts make necessary inroads, the labor force will doubtless show an absolute decrease. Under these conditions, unrestricted price-bidding for essential commodities will merely raise market prices. These will be reflected in turn in expanded wage costs and inflated prices for machinery and related equipment, which are in turn labor products. The outcome is an alteration in distributive or income results without even approximate ratio of increase in volume of product. Profits mount amazingly in war-stimulated industries; labor moves toward such industries at rapidly advancing wage rates; non-transformable industries, not essential to the purposes of war, decline in material and financial productiveness. Price-bidding has caused a shifting of activities, an increase in market values; but aggregate product has diminished. The lure of advancing profits resulting from the raising of price margins yields no generally desirable social results. Profit is not product, and profit can serve as an incentive to product only when enlarged or better organized or more efficient labor force can be applied to tasks in hand. During the past year there has been no enlargement on better organization or demonstrable increase in the efficiency of labor. A reverse experience is the regrettable fact.

There has been no lack of price-bidding for the services of labor. With war industries setting the pace, wage rates have shown unprecedented advance. The following rates per hour are illustrative of minimum wage standards now prevailing in shipyards. These rates are for an eight-hour day, with time and a half for over-time, and double time for Sundays and holidays:

|                                         | Rate per Hour |
|-----------------------------------------|---------------|
| Anaesthetists .....                     | \$0 87 1/2    |
| Hammer and machine forgers, heavy ..... | 1 35          |
| Bolt makers .....                       | .72 1/2       |
| Electric welders .....                  | .65           |
| Boiler makers .....                     | .70           |
| Erecting leaders .....                  | .70           |
| Drillers .....                          | .55           |
| Chippers and calkers .....              | .70           |
| Painters and polishers .....            | .60           |
| Laborers and helpers, from .....        | 40 to 46      |

Changes in wage distribution between 1915 and 1917 strikingly emphasize the upward trend of wages.

Massachusetts figures, drawn from returns made by workers in whose cases compensation for industrial injuries was awarded, are quite illustrative:

| Weekly Wage Group  | 1915<br>Per Cent | 1916<br>Per Cent | 1917<br>Per Cent |
|--------------------|------------------|------------------|------------------|
| Under \$10 .....   | 26 41            | 15 64            | 7 92             |
| 10.01-15 .....     | 46 39            | 46 98            | 21 02            |
| 15.01-20 .....     | 18 24            | 24 60            | 37 53            |
| 20.01-25 .....     | 6 30             | 4 26             | 18 35            |
| Over \$25 .....    | 2 66             | 3 52             | 15 18            |
| Average wage ..... | 13 13            | 14 53            | 18 39            |

It will be noted from these figures that in 1915 only 2.66 per cent of the workers received a wage in excess of \$25 per week; in 1916, 3.52 per cent; in 1917, 15.18 per cent. At the same time, the percentage of those earning less than \$10 per week declined from 26.41 in 1915 to 7.92 in 1917.

The effect on wages of the expansion of munitions manufacture is well indicated by the following figures of a well-known New Jersey plant.

|                           | Male Workers Over 16 Years of Age<br>Per Cent of Total   |       |       |       |
|---------------------------|----------------------------------------------------------|-------|-------|-------|
|                           | 1916                                                     | 1917  | 1916  | 1917  |
| Under \$15 .....          | 812                                                      | 89    | 36 4  | 2 5   |
| \$15 but under \$20 ..... | 815                                                      | 450   | 36 5  | 12 6  |
| \$20 and over .....       | 605                                                      | 3,023 | 27 1  | 84 9  |
| Total .....               | 2,232                                                    | 3,562 | 100 0 | 100 0 |
|                           | Female Workers Over 16 Years of Age<br>Per Cent of Total |       |       |       |
|                           | 1916                                                     | 1917  | 1916  | 1917  |
| Under \$12 .....          | 1,412                                                    | 1,245 | 100 0 | 45 8  |
| \$12 and over .....       | ...                                                      | 1,477 | ...   | 54 2  |
| Total .....               | 1,412                                                    | 2,722 | 100 0 | 100 0 |

It will be noted that in the case of male workers only 27.1 per cent earned \$20 or more per week in 1916. In 1917, 84.9 per cent earned \$20 or more. In the case of the female workers, none earned as much as \$12 per week in 1916. In 1917, 54.2 per cent were earning \$12 or more.

#### LABOR DEMORALIZED BY PRICE-BIDDING

No one endowed with adequate fellow-feeling would suggest that workers are not justified in making their demands as urgent as possible and in gaining every advantage from the present labor shortage that may honestly be turned to account. They have at least as fitting a claim as have other classes which are profiting by the war. Their necessities are greater, and their real gains in the goods that money will buy will in any case not be appreciable. There is a vast difference, however, between a justification of their effort to alter the distribution of income and the maintenance of a view that increased wages will enlarge industrial output. The Director General of Railways is about to put into force wage increases for railway workers which will aggregate several hundred million dollars. Will the workers' contribution to transport services show any corresponding augmentation? The answer is reflected in the increase of freight and transportation charges already in process of application. There will be no change in output of railway services attributable to wage increases. The same is true of the wage-bidding of munition and ship-building plants. Labor has been demoralized. Workers have become bargain hunters. Labor turnover has assumed unwanted proportions. A round of visits to ship-building plants made nine weeks ago showed many groups of workers vigorously discussing wage-rates and earnings, rather than bolting ship-plates or driving rivets. Superintendents and bosses were exercised and often incensed, but helpless. Governmentally standardized wage-rates have since afforded a measure of improvement, and

more rigorous control over the distribution and migration of workers will sooner or later do much more; but what has been done cannot be undone.

"It is the conditions which surround the worker that determine his efficiency. Improvements in health, sanitation, housing and other elements in the home environment have a bearing on industrial efficiency and by them are the betterments of the worker to be measured. Price-bidding thwarts what the local environment stimulates. It leads to dissatisfaction, dissipation and to misplaced energy. Its lesson is therefore the same as that of other price bidding whether in food products or in raw material. There is an increase of waste but not of product. Increased production comes from an organization of the hitherto unused or partially used elements of the working population. It is easier to raise lower groups to a higher efficiency than to divert well-paid workers from one occupation to another. A new industry in war time or in peace should build up its own labor force out of the misplaced or partially used workers. A worker's training can be readily acquired if the discipline and oversight is what it should be. The increase of production mainly depends on moving those below the normal standard of living up to this standard and not on giving more to those above this standard.

"Why the moving of workers up to a decent standard of living is a productive problem is clearly shown by the rejection of recruits in the recent draft. Above 35 per cent of the recruits were rejected, of which 60 per cent were for removable causes. It is also estimated on the basis of these facts that three-fifths of those between 31 and 45 are physically unfit for military duty. A half of the working population are thus below the normal level of physical vigor and of these, more than a half are disabled from preventable causes. When we realize the reduction in labor efficiency which these defects cause, we can readily see what their removal means. Industry would gain both in gross and net product if the cost of removal were assessed against it. This shows what a living wage with proper care of health, sanitation and housing would do. The interest of every portion of society is promoted thereby. The sacrifices of the poor add no one. They reduce both the gross and net return of industry.

#### HOW REALLY TO BENEFIT LABOR

"The way to benefit the higher class of laborers is not by higher wages but by increased inducement to save. Price bidding makes spenders and increases both extravagance and waste. Saving aids production and modifies workers in ways which increase production. The man who spends all he earns, be he a worker or a salaried man, is dependent on a capitalist class, and to increase production will in the long run be the victim of the social order his defects make necessary. It is higher rates of interest which the uplift of the worker demands. He needs motives to check spending and not a freedom to indulge his caprice."<sup>3</sup>

Much can also be done by the working out of a comprehensive policy of labor distribution through a coördinated system of labor exchanges. The present indiscriminate practice of drawing workers from their present attachments by peripatetic employment agents and by promiscuous advertising cannot be too strongly

condemned. A centralized system of registration with local agencies to estimate local needs and to facilitate the distribution of workers would afford a vast improvement over prevailing anarchical conditions. A sample of what might be done in this direction has been afforded by English experience and by recent experimentation in the State of Ohio.<sup>4</sup>

A marked shortcoming of the competitive price-regulating régime, often unrecognized, is the wasteful duplication and lack of unity in the use of large-scale facilities of production and marketing. It is a well-recognized fact that large-scale producing units, involving the use of highly specialized and highly expensive equipment, tend to become cut-throat in their competitive practices. Some sort of common arrangement with regard to marketing practices is an inevitable outcome. But, short of actual combination, these arrangements, though financially salutary, have contributed little to the attaining of operating unity, so essential to the elimination of waste. Pools have been effective as dividend savers, but useless in directly promoting growth of product and of services from coördinated management. Railroad history affords striking illustrations of this situation. Railroad pools were never formed for any other purpose than control over rates. The carriers discovered through sad experience that competitive rate-warfare was disastrous to strong and weak roads alike. The pool was a resulting device to prevent rate-cutting by apportionment of competitive traffic or of the receipts from such traffic among the roads concerned. Pools were declared illegal by the courts, but subsequently established understandings have been no less effective. It is no fortuitous circumstance that rates between competitive points are the same on rival roads with equal facilities, nor is it mere chance that rate increases are simultaneously announced by rival lines. Strictly viewed, these agreements may have been illegal; but they have been winked at because public authority has had power to prevent arbitrary increases.

#### WASTE THROUGH LACK OF UNITY

But the mere existence of pools and agreements operating under public sanction did not produce operating unity. To the contrary, examples of uncoördinated organization and operation are legion. In the New York district there is an extreme example of wastefully competitive terminal facilities, where topographical conditions would permit high operating efficiency. Engineering experts have pointed out again and again how certain belt and marginal railroads with bridges or tunnels would bring the terminal facilities of the harbor into a great flexible unit. But the monopoly of a single road has forced continued reliance on scattered, inadequate and wasteful arrangements.

Some years ago the Wabash Railroad began to build a subsidiary line into Pittsburgh. The money spent by the Wabash in furthering its plans added to that spent by the Pennsylvania in opposing them would have paid for the construction of an adequate Pittsburgh terminal. Of what inestimable value such a terminal would have been during the past two years of traffic congestion in Pittsburgh!

<sup>3</sup>Cf. of two articles by W. M. Lelerson in *The Survey* for March 30 and April 20, 1918. Also Leschier: "A Clearing-House for Labor," *Atlantic Monthly*, June, 1918.

<sup>4</sup>Patten, *supra cit.*



In Chicago twenty-five trunk lines enter the city. These have twice the trackage requisite for the handling of freight under a unified terminal system. Every day some 2000 tons of through freight, in less than car-load lots, are hauled by truck from inbound to outbound stations. In fact, almost the whole of Chicago's terminal system is obsolete and needlessly inefficient. Admirable plans of reorganizations have been worked out; but these have been fruitless because individual companies will not surrender strategical advantages acquired in the early days of their development. One cannot blame the managers of the roads. They have but followed the competitive creed under which our railroads have developed. Within the past year, under the stress of war, there were efforts at coordination, but these could not be made completely effective under private management. The Government has taken over the roads, in all likelihood for a period of years. As President Wilson has said: "The group of railway executives who are charged with the task of actual coordination and general direction performed their difficult tasks with patriotic zeal and marked ability, as was to have been expected, and did, I believe, everything it was possible for them to do in the circumstances. If I have taken the task out of their hands, it has not been because of any dereliction of failure on their part, but only because there were some things which the Government can do and private management cannot."

What is true of the railroads in war times is measurably true of other complicated, large-scale, competitive units in other fields of production and distribution.

The considerations thus far urged have received more or less conscious recognition in the practices and policies of the nations at war. Aside from our own, we know most about the British experience.<sup>5</sup>

#### WAR-TIME EXPERIENCE OF GREAT BRITAIN

Starting with a strong predilection for *laissez faire*, British control of industry has passed through three phases. The first, extending over a period of less than a year, was one of tentative action, looking only toward obvious measures of self-protection. The second, lasting for some seventeen or eighteen months, was a period of determined regulation. The Government's chief concern was that of increasing the output of munitions of war, of securing supplies for the army at prices below those of the market, and of regulating shipping. The third phase, beginning at the end of 1916, has been one of stringent control, governmental regulation of the production, distribution and consumption of food being its most prominent feature. "The doctrine of *laissez faire*, still respected in 1914, had by the end of 1917 passed into at least temporary oblivion."

Control over the prices and distribution of essential metals are typical of British practices. Through the medium of this control, the Ministry of Munitions achieved triumphant results during the first year of its activity.<sup>6</sup> This involved interferences with the

normal course of trade which went beyond even the control of employers' profits and the restriction of trade unions' liberties and practices. Raw materials were controlled throughout the processes of conversion into munitions. "The great lesson of the early months of the War," said Mr. Montagu in an August, 1916, speech before Parliament, "was that munitions cannot be obtained merely by ordering. You have got to see that the man who takes your orders has the plant and the labor; you have got to follow up the work process by process; you have got to provide from the beginning to the end everything that is necessary. That is the cardinal principle of the Munitions Department."

Following this principle, the Government early turned its attention to the supplies and prices of iron, steel and copper. During 1915 market quotations for these metals had advanced rapidly. Conditions in the import trade were largely responsible. American supplies had been so largely diverted by home demand that semi-steel could scarcely be obtained. Freight rates, too, rose from 15s. to 65s. per ton. As a result, the price of bar-steel, used in shell making, advanced from £7 15s. in January, 1915, to £11 in July, and to £14 in December. American billets, which early in the war brought \$5 per ton c.i.f., so far as available at the end of the year, sold for £10 10s. Hematite rose from 71s. a ton in January to 115s. in December. The increased value of skilled labor needed to transform forge pig into bar pig was reflected in a changed price ratio of from 1 to 2, to 1 to 3.<sup>7</sup>

#### GOVERNMENT FIXES MAXIMUM PRICES

This was the status of price movements in January, 1916, when the Government resolved to prevent further appreciable rise in prices. Maximum prices for all finished iron and steel goods were fixed. These were revised in April and again in November. The following quotations will illustrate the stabilizing effect of these measures:

|                              | January, 1915 | January, 1916 | December, 1916 |
|------------------------------|---------------|---------------|----------------|
| Steelship plates, per ton... | £8            | £11 10s       | £11 10s        |
| Iron ship plates ...         | £7 15s        | £11           | £11 10s        |
| Steel sheets (singles)....   | £8 5s         | £13 10s       | £14            |
| Common iron bars ...         | £8            | £10 10s       | £10 15s        |
| Heavy steel rails ...        | £6 7s 6d      | £11           | £10 17s 6d     |

At the end of February maximum rates were set for pig-iron below those ruling in the market. On Feb. 22, Cleveland No. 3 sold in Glasgow for 98s. 6d.; on the following day there were rumors that the Government would insist on transactions at 82s. 6d. The market broke forthwith, and 2500 tons were sold at 87s. 6d. Private transactions continued for some weeks, but gradually waned until the metal exchanges in London and Glasgow lapsed into lifelessness.

The Government next took steps to stabilize the price of iron ore, of which in 1916 some 6½ million tons were imported. But guarantees were given, both in freight rates and in ore prices, to meet any differences that might arise between fixed prices and actual costs. Precautionary notice was served that the maximum prices for steel and iron were based upon abnormal costs and conditions then prevailing, and must not be assumed to indicate differences in relative values obtaining in the several districts before the war, or which might obtain again after the war.

<sup>5</sup>My illustrations of railway conditions have been drawn from one of a series of five striking articles, by T. W. Van Meter, now running in *The Traffic World*. The article in the number for May 11, 1918, affords a significant discussion of the faults of private management.

<sup>6</sup>An excellent discussion of the British experience will be found in Gray, H. L., "War-Time Control of Industry," *The Macmillan Co.*, 1918.

<sup>7</sup>Gray, *supra* cit.

<sup>8</sup>My facts are drawn from Gray, *supra* cit.

On Feb. 29, 1916, the Government forbade speculative trading. Thereafter, dealings in iron, steel, copper, zinc and certain other metals became unlawful except in cases of direct transfer by owner to consumer or consumer's agent. During January and February the prices of copper, lead and iron, owing largely to speculative dealings, had reached previously unprecedented war levels. Copper was higher than since 1907, and the other metals had broken previous records. Compared with 1913, the quotations were:

|                | Highest Price<br>Since the War | Highest Price<br>in 1913 | Lowest Price<br>in 1913 |
|----------------|--------------------------------|--------------------------|-------------------------|
| Copper per ton | £108                           | £78                      | £62                     |
| Lead .....     | £35                            | £22                      | £15                     |
| Spelter .....  | £120                           | £27                      | £20                     |
| Iron .....     | 98s.                           | 70s. 6d.                 | 48s. 6d.                |

Under the new prescriptions iron was to be sold at 82s. 6d. Copper was imported, so that its price could not be fixed. There have since been marked fluctuations in copper prices; but, at least, profits of home speculators were eliminated.

#### ECONOMY AND EFFICIENCY IN THE USE OF MATERIALS

The next step was that of securing economy and efficiency in the use of metals. Restrictions were first put upon the exportation of iron and steel to neutrals. As early as July, 1915, the exportation of high-speed steel had been prohibited, except under license; and thenceforth only a small part of the licenses asked for were granted. Early in 1916 neutral markets were further closed, except through occasional grant of permits to adjust the balance of trade. Of this the shipment of steel rails to South America is an example.

As between home consumers, priority regulations ruled. In the beginning they affected only controlled establishments; but by March, 1917, more than 90,000 firms had been brought within their scope. With an underlying purpose of securing essential supplies to industries in the order of war-time importance, they provided, relative to steel and copper wire, that no order (other than for shell-discard quality) should be accepted by a manufacturer except with Government approval. Such approval was safeguarded by detailed regulations; and each week manufacturers were required to make full returns to the Director of Steel Production of all steel manufactured or delivered.

#### PRIORITY PRINCIPLE APPLIED TO LABOR

The principle of priority in industrial work was next extended to contracts for the employment of labor under a Restricted Occupations Order. Industries not conducive to military ends were by these means forced to the wall.

"By the spring of 1917 the Government was in pretty complete control of the vast business of manufacturing munitions, especially in control of the supply of iron and steel. Its first endeavor had been to enlist in its service private engineering and shipbuilding firms and to attempt the mobilization of labor; it had ended by fixing the price of iron and steel by determining the allotment of these and other metals to the manufacturer and by directing the supply of labor into essential trades. It had, in short, extended its control from producer to consumer, undertaking almost everything except the appropriation of the mines and the works."

Judged by any standard of the adapting of means to

ends, British experimentation has been a success. Employers have complained little except in non-essential trades. Some would have welcomed a more liberal export policy in order to share in the higher prices of the world market. But essential industries have been crowded with orders, and business has been continuously active. A liberal profit margin has prevailed, so that little friction has developed between manufacturers and the Government. And most of all, ships, munitions and other war essentials have been turned out in growing volume.

#### PRICE-FIXING GOOD ECONOMY

Great Britain has been impelled further toward state control of industry than the United States has thus far gone. We are still much more largely reliant than they on the voluntary cooperation of citizens. Only time can tell how far we shall go in their direction. But in any case, governmental judgment is quite likely to coincide with that recently expressed in the columns of a popular weekly:\*

"Of course price fixing curtails production. With more pinches there will probably be more criticism of it on that ground. When coal prices were soaring, without a check in sight, mines that could not be worked profitably at anything like normal prices were opened up. Almost any sort of contrivance in which iron could be made found a profit in operating when that commodity sold round seventy dollars a ton. When the Government fixed the price at thirty-three dollars resurrected and improvised furnaces had to shut down.

"But price-fixing, though it does cut out a certain amount of extravagantly dear production, is good economy. The country is in a sounder position with somewhat less iron at thirty-three dollars a ton than it would have been with a somewhat greater output at seventy dollars. The increased supply of either coal or iron would have been relatively small. In the case of coal the real famine was in transportation rather than in fuel." An increased supply at the mines would have done no good when cars were not available to haul it. The iron pinch is quite as much a lack of transportation and labor as of metal. The stock of materials will answer if it is handled to good advantage.

"The objections to abnormal prices are psychological and political as well as economic. Few things in this sordid world are more likely to put a nation out of tune than having to pay double or treble the accustomed price for a necessary article of universal use. At best, high prices are bound to be a sufficient affliction during the war. Limiting the price of certain basic articles by Government action would be justified as a political measure, even if it could be shown, by some miraculously comprehensive calculation, that there was no net economic gain in it."

Columbia University,  
New York City.

Exports of gold for April 1918 were 3560 thousand dollars with imports exceeding 2745 thousand dollars, leaving a balance of gold movement against us in excess of 814 thousand dollars.

\*Saturday Evening Post, June 1, 1918.

<sup>1</sup>See tabulation on p. 72. Compare output of locomotives and cars with that of the various raw products.

\*Gray, *supra* cit. p. 47.

# Flotation Apparatus, Their Design and Operation

## Classification and Summary of the Types of Machines—Capacity, Air and Power Consumption—Cost of Equipment

BY A. W. FAHRENWALD

IN THE last three years great strides have been made in mechanical appliances for the purpose of concentrating ores by the flotation process. Many patents have been taken out for such devices, and a large number of them have been put into operating mills and are giving satisfactory results; others have not reached such wide application.

Before proceeding to a discussion of the various types of apparatus used in the process, it will be necessary to classify them. The classification which will follow does not include types that have served as a link in the chain of designs leading to the present developed system. Neither will it include the so-called "film" flotation processes, as their field of usefulness seems to be quite limited, and since most of these processes or methods are expensive because of the limited amount of mineral that can be floated at one time on the surface film of water. They can not handle finely divided slime, yet it is certain that the present popularity of "froth flotation" depends on its success in the treatment of ore-slime. For this reason it is easily seen that the application of machines using the "skin" or "film" principle is limited. It is noteworthy, however, that McQuisten's method is at present in use for the treatment of table middlings at the Morning Mill, at Mullen, Idaho. Barite and siderite are there present as gangue minerals in a middling containing zinc and lead sulphides. As these heavy gangue minerals can not be separated by gravity methods of concentration, the alternative of grinding them fine enough for froth flotation or of treating them by film flotation has so far enabled the latter to survive the competition of froth flotation. At the ore-testing plant of H. E. Wood, of Denver, a film flotation machine is also removing molybdenite from a low-grade ore. There is little doubt, however, that froth flotation could be used for every separation of minerals that is now being accomplished by film flotation, providing the material were ground fine enough.

The following classification, then, includes apparatus most widely used in practice:

- I. Straight mechanical frothing machines.
  1. "Minerals Separation" type of machine.
  2. Janney machine.
- II. Mechanical-air frothing machines.
  1. Minerals Separation sub-aeration machine.
  2. Janney mechanical-air machine.
  3. Kollberg-Kraut (K. & K.) machine.
- III. Pneumatic frothing machines.
  1. The Callow pneumatic machine.
  2. Flinn-Towne machine.
  3. Cole-Bergman machine.
  4. Inspiration machine.

5. Launder machine (Snyder).

IV. Gravity frothing machines.

1. So-called "cascade" or "hydraulic" flotation machines.

The above classification is based on the fact that all machines recover the mineral sought by forming a froth or foam. Without the formation of a froth, the physics of which has been discussed frequently in the technical press,<sup>1</sup> no mineral will be concentrated. In the important froth flotation processes the mineral-carrying froth is produced by either beating air into the pulp by mechanical means or by injecting it in the form of small bubbles.

### I. STRAIGHT MECHANICAL FROTHING MACHINES

Machines of this class probably were the first to receive practical application. They advanced regularly

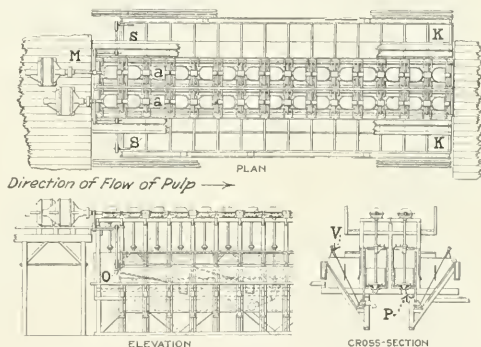


FIG. 1.—THE MINERALS SEPARATION MACHINE

in design, reaching a fairly high state of perfection before the pneumatic type was introduced.

1. The "Minerals Separation" type owes its present state of development and perfection to the metallurgical staff of Minerals Separation, Ltd., among whom Froment, Cattermole, Picard, Sulman, Ballot, Nutter and Hoover deserve special mention. The ideas of many others have also been taken over by this company.

The Minerals Separation machine used at the present time will be described best by reference to the installation at the Washoe Reduction Works of the Anaconda Copper Company.<sup>2</sup> Fig. 1 shows the machine at various angles.

The feed is introduced into the first agitation box at the motor end of the machine, M. From this box

<sup>1</sup>See "Flotation in the Coeur d'Alenes," C. T. Rice, *Engineering and Mining Journal*, Vol. 105, p. 709 (Apr. 20, 1918).

<sup>2</sup>"On the Molecular Physics of Ore Flotation," Coghill and Wright, *This Journal*, June 1, 1918.

<sup>3</sup>"Flotation Concentration at Anaconda," *Bull. A. I. M. E.*, March, 1916.



it passes to a second box through an opening O in the partition, as shown in the elevation. From this second agitation compartment the pulp passes into the first spitzkasten S, where the first concentrate froth is formed and removed by means of a paddle. The pulp remaining passes through a pipe P, the inlet to which is controlled by a valve stem V, to the third agitating box A. From this agitating box the pulp

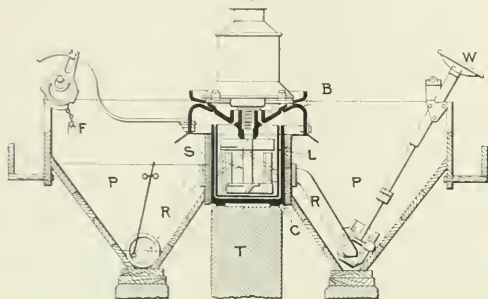


FIG. 2.—JANNEY MECHANICAL FLOTATION MACHINE

passes through the second spitzkasten, and so on through the machine until the pulp is introduced into a fourteenth or last spitzkasten K. The discharge from the last spitzkasten leaves the machine as tailings. The first four to seven spitzkasten make finished concentrates and the remaining ones make middlings that are returned to the system. The drawings show a double machine—each machine however, being run as a separate unit. The line shaft is driven by a 150-hp. motor at a speed of 385 r.p.m. and requires about 100 hp. under load. The vertical shafts carrying the impellers revolve at a speed of 225 r.p.m. The impellers have four blades placed at right angles and inclined 45° to the vertical, made of gun metal, 18 in. in diameter, giving a peripheral speed of 1,060 feet per minute. Each pair of impellers is so arranged that they revolve in opposite directions, which tends to balance the side thrust on the line shaft. The bevel gears that drive the impeller shaft are cut-steel and run in grease. The impeller shaft is supported both vertically and horizontally by ball bearings.

The machines are made of California redwood; the agitator boxes are further lined with hard maple extending about 18 in. from the bottom of the box.

Each machine makes three products: concentrate, which goes to the dewatering division; middling, returned to the head of the machine; and tailing, to waste. Concentrate is taken from the first three to five spitzkasten and middling from the last nine to eleven.

**2. Janney Machine.** Fig. 2 shows the mechanical machine,<sup>4</sup> which is constructed of cast iron, with the exception of the spitzkasten. The whole machine is

attached to a main casting C which sets on a foundation of concrete or timber T in the middle (Fig. 2). Inside this main casting is a liner casting L which takes the wear, and which is baffled on the lower portion so that the pulp receives a very violent agitation. Above the main casting sets a top liner B and a support for the motor. A shaft S, on which there are two impellers, is screwed to the lower end of the motor shaft, and turns with the rotor at a speed of about 570 r.p.m. It is made heavy enough, and the bearings in the motor are of sufficient size, so that there is but little vibration. The impellers on these shafts are of two sizes; the lower one is the smaller and revolves inside the baffle on the liner, while the upper one revolves just above the baffles, and throws the pulp up and out into the spitzkasten P on either side of the agitating chamber.

The Janney machines are of the double spitzkasten type, i.e., each agitator serves two spitzkasten. On each side of the agitating chamber there are two open-ended circulating pipes R, which lead from the bottom of the spitzkasten up and into the same agitating chamber. Each spitzkasten is divided by a baffle or partition, which prevents the pulp from flowing through the series of machines without passing through the agitating chambers. Any desired height of pulp-level is maintained by regulating a gate between the spitzkasten with a hand wheel W, then the rate of flow from "spitz to spitz" depends entirely upon the volume of feed entering the machine. The amount of pulp circulating in each unit machine builds up to its capacity, and then remains constant, due to the regulating gate between the spitzkasten.

The circulating feature of the machine allows the pulp to be treated many times. When the pulp is thrown out from the agitating compartment into the

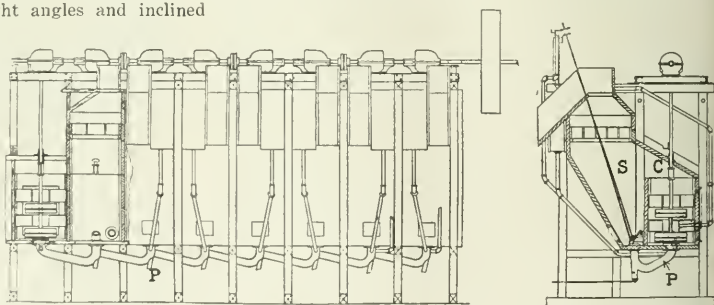


FIG. 3.—MINERALS SEPARATION SUB-AERATION TYPE OF FLOTATION MACHINE

spitzkasten a froth is produced. A froth remover F driven by a small motor installed at one end of the row of machines removes it as formed.

A typical installation of Janney mechanical frothing machines (known as a multiple-series arrangement), consists of two mixers or "emulsifiers" and fifteen Janney mechanical machines in a row. In such an installation the feed is divided among the first five cells. The tailing of each of these five cells enters the sixth cell and from the sixth cell it advances from "spitz to spitz." The slope required is 1½ inches per foot.

This machine is adapted to the treatment of a classified feed or of ores of high mineral content, and is

<sup>4</sup>Catalog, Stimpson Equipment Co., Salt Lake City, Utah.

especially adapted for treatment of low-grade concentrate produced on tables or vanners. The feed should all pass 40-mesh for best results, while the percentage of solids in the feed should range from 20 to 23 per cent.

A feature of this machine distinct from most other mechanical agitation machines lies in the individual motor drive for each agitator compartment. This arrangement is accompanied by the many advantages accruing to any individual-motor-driven machine, but its high first cost would usually be beyond the means of the small operator.

## II. MECHANICAL-AIR FROTHING MACHINES

In most cases these machines have been introduced since the debut of the pneumatic system of floating minerals. The object in this machine is to combine the advantages of both injected air and mechanical agitation. This combination increases the chance that any particle will be caught in traveling a given distance.

1. **The Minerals Separation Sub-aeration Machine.** As seen from the illustration,<sup>5</sup> Fig. 3, pressure air is admitted to the pulp conduits P leading from the spitzkasten to the agitation compartment next in succession, in order to make this air available in lifting mineral to the top of the spitzkasten where it can be skimmed off. The agitating compartments are closed at the top by covers C set on an incline in such a way that the air rising to the top in the agitating compartment is conducted to the spitzkasten S, being thereby utilized for the purpose of carrying the mineral values, as noted.

The above construction led to a design of greater simplicity, known as the "Hebbard" type of minerals separation machine,<sup>6</sup> which consists of a long rectangular tank without any partitions, in which a number of agitators revolve, while air is injected under each impeller. In order to limit the agitation to the lower part of the machine, and to provide an area of comparative quiet in the upper part, a system of baffles is arranged above the agitators. As a consequence the froth is given a chance to separate in the upper portion of the rectangular tank, and flows off on both sides into lengthwise launders provided for the purpose. This, it will be seen, is a phase of operation similar to that of pneumatic machines where the froth, formed in the one compartment, flows over into launders.

This machine no doubt marks an important step<sup>7</sup> in

the development of the Minerals Separation flotation system. The simplicity of the machine is remarkable and does away with the bulky spitzkasten and the mechanical device for removing the froth. The floor room required for the machine is thus reduced to a minimum which is an important point in mill practice.

2. **Janney Mechanical-Air Machine.** The mechanical agitation in this machine<sup>8</sup> is obtained in the same manner as in the Janney straight mechanical machine. There is a continuous circulation of pulp through the mixing chamber and over the air mat. From the emulsifier E, Fig. 4, the pulp and oil, thoroughly beaten together, pass to the agitating chamber A of the first machine through a pipe P. From here it overflows continuously into the spitzkasten S. The froth flows over the gate G, while the un-retained pulp flows over the gate B, which controls the height of pulp in the "spitz." From here the pulp flows through a pipe, R, to machine No. 2, and so on down through the series.

The bottom D of the spitzkasten is a cast-iron pan, divided into three compartments, the whole being covered by four layers of cross-stitch palma twill. The pan is divided into three compartments so the air may be regulated to meet the varying hydraulic head

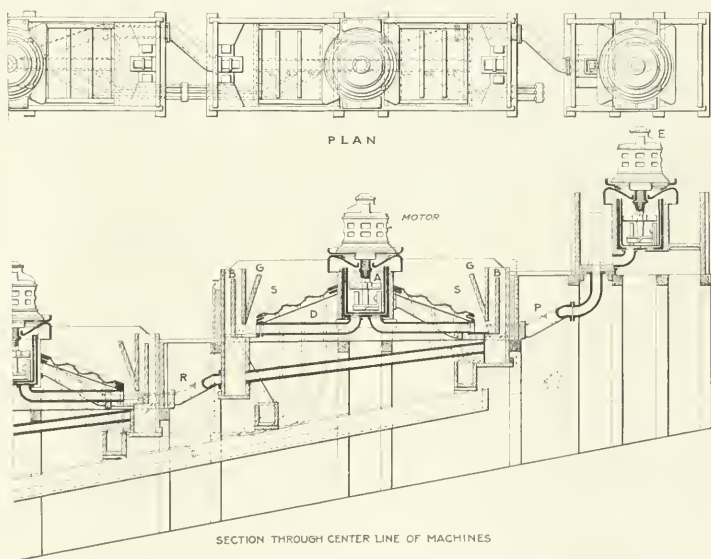


FIG. 4.—JANNEY MECHANICAL-AIR MACHINE AND EMULSIFIER.

within the spitzkasten, as a pressure of from four to five pounds is required.

These machines may be installed end to end, or side by side, usually in a series of one mixer, or emulsifier, and five flotation cells. The latter arrangement is used in small plants, as it is more compact: the floor space required is approximately 5 by 16 feet per unit, with a drop of 3 feet between cells. For the end-to-end arrangement the floor space required is approximately 4 by 16 feet, with a drop of 3 feet between cells.

3. **The Kollberg-Kraut machine** is a complete unit,

<sup>5</sup>Bull. A. I. M. E., Sept., 1916.

<sup>6</sup>Ibid., p. 1644

<sup>7</sup>As recorded by Laist and Wiggin in an article, "Flotation Concentration at Anaconda, Mont.," Bull. A. I. M. E., Sept., 1916, p. 559, this machine was a failure on account of too much disturbance in the upper part of the machine for the proper removal of froth. They do not say whether the top position was baffled or not.

<sup>8</sup>Catalog, Stimpson Equipment Co., Salt Lake City, Utah.

requiring no blower, air compressor, or pre-agitation. See Fig. 5, which shows details of this machine as used at the Burro Mountain Mill,<sup>9</sup> Tyrone, New Mexico.

The feed enters at one end of the machine through a five-inch feed pipe F, the tailings being discharged at the opposite end through a four-inch pipe T, while

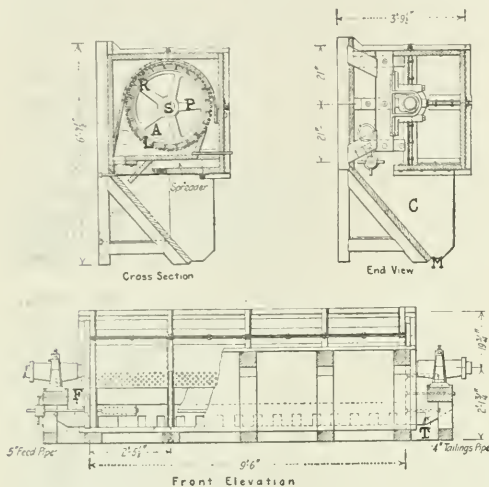


FIG. 5.—DETAILS OF THE FLOTATION MACHINE AT THE BURRO MOUNTAIN MILL.

the concentrate is discharged over the lip M of the frothing chamber C into a suitable launder. An adjustable level-control device is provided which maintains the proper level of pulp in the machine, which in return furnishes the correct height of the bubble column in the frothing chamber.

The machine consists of a cylindrical housing about 10 ft long and 30 inches in diameter. Inside the aëration chamber A is located a rotor R which consists of a  $3\frac{7}{16}$ -inch steel shaft S, on which is mounted four cast-iron spiders P for carrying the lagging and riffles L of the rotor. The lagging forming the periphery of the rotor is so spaced as to leave a  $\frac{1}{4}$ -inch opening between each piece. There are 16 of these pieces and each is provided with four hard-wood or steel riffles, which run the entire length of the rotor. The rotor revolves at 180 r.p.m. and has a clearance of three-eighths inch between its outside periphery and the inside surface of the aëration chamber.

The rotor shaft passes through the two end plates of the machine by means of two air ducts, of ample size

to furnish all the air necessary to thoroughly aërate the pulp as it is revolved. There is no leakage of air through these air ducts, but a continuous influx of air from the atmosphere which is discharged by centrifugal force through the air slots between each of the 16 pieces of riffled lagging forming the periphery of the rotor. It immediately comes in contact with a thin film of pulp which has been circulated by the rotor, and the revolving pulp is thoroughly aërated in the space between the outside periphery of the rotor and the inside surface of the aëration chamber.

The housing can be removed for replacing the riffles, which last from four to six months. The floor space required by this machine is 4 feet by 14 feet, and from 6 to 8 hp. is required to operate it.

### III. PNEUMATIC FLOTATION MACHINES

The first application of pneumatic flotation for the treatment of ore was made at the mill of the National Copper Company at Mullen, Idaho, which was designed and constructed by J. M. Callow.<sup>10</sup> Construction was started on Aug. 14, 1913, and the plant went into operation about April 10, 1914. The Callow pneumatic system was a success from the start, and it is interesting to note that it had been so thoroughly thought out in its initial design that during three years of operation little or no change has been made. Other machines operating on the pneumatic principle, in general, have also been successful.

1. The Callow Pneumatic Machine. Fig. 6 illustrates the various elements composing the Callow process in general.

In the mixer A, operated by compressed air, oil, air and water are mixed and emulsified; the same type of

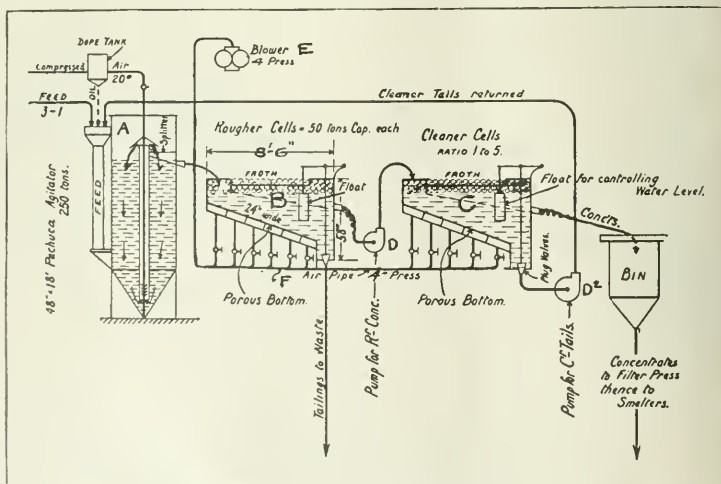


FIG. 6.—CALLOW PNEUMATIC FLOTATION PROCESS

apparatus (Pachuca tank) is in common use in cyanide works. In case the oil or frothing agent can be fed into the crushing machine or tube-mill, this mixer can

<sup>9</sup>"The Burro Mountain Concentrator," by L. C. Blickensderfer, *Eng. and Min. Journal*, Jan. 14, 1917.

<sup>10</sup>"Notes on Flotation," Historical sketch, *Bull. A. I. M. E.*, No. 108, p. 2321-2339, Dec., 1915. "Callow Pneumatic Flotation Process," *3rd, and Chem. Engrg.*, v. 13, p. 571-572, Sept. 1, 1915; *Eng. and Min. Jour.*, v. 100, p. 919-923, Dec. 4, 1915.



be dispensed with, the tube-mill discharging direct into the separatory cell. It has been conclusively proved that agitation of the pulp, before subjecting it to the bubble column, is not necessary to successful flotation by the pneumatic method.

The initial or roughing cell B consists of a tank about 9 feet long over all, and 24 inches wide, with a bottom inclined at from 3 to 4 inches per foot, 20 inches deep at the shallow end and 45 inches deep at the other end. It may be built of either wood or steel, but wood construction is preferable.

Fig. 7, shows the cell in detail as used at Inspiration." The bottom of the tank consists of a porous medium made of four thicknesses of loosely woven canvas twill," properly supported by a backing of perforated metal to prevent its bulging under air pressure. Through this porous medium compressed air is forced by the blower E, Fig. 6. The space underneath this porous medium is subdivided into eight compartments, each connected by an individual pipe and

of the side gutters to the pump D (Fig. 6) and then to the cleaner cell C, of the same construction as the rougher. Usually one cleaner serves four roughers and operates under a slightly lower air pressure.

A given number of cells may be run either in parallel or in series without any sacrifice in capacity. On one ore the series-treatment gives a slightly cleaner tailing; on others it does not. Usually two cells in series is sufficient. In a heavily mineralized ore the series arrangement is a decided advantage, as the possibilities of any particle of mineral to escape are lessened.

2. **The Flinn-Towne Machine.** In Fig. 8 is seen a single cell of this type. It operates on the pneumatic principle, although the application is somewhat differ-

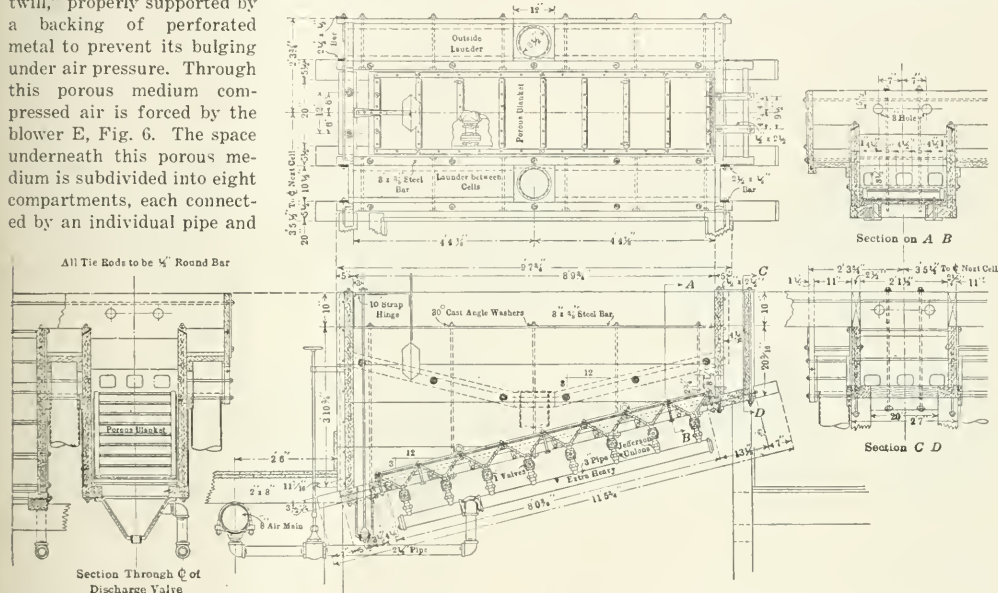


FIG. 7.—DETAILS OF CALLOW PNEUMATIC FLOTATION MACHINE

valve to the air main. By this means the pressure in each compartment can be regulated to correspond to the varying hydraulic head within the tank, and so discharge a uniform amount of air throughout the length of the tank. A pressure of from 4 to 5 pounds is generally used, each square foot of porous medium requiring from 3 to 10 cubic feet of free air per minute.

Each longitudinal edge of the tank is provided with a lip and an overflow gutter for the reception of froth to be discharged. The lower end of the tank is furnished with a spigot discharge fitted with a float-operated plug valve to maintain a uniform water-level within the tank and thus, in turn, maintain a uniform and constant discharge of froth under all varying conditions of feed incident to practical milling operations. The water-level may, of course, be varied, but is usually maintained at from 10 to 12 inches below the level of the overflow lip. The tailing is discharged through the spigot and the frothy concentrate is conveyed by means

ent from that of the Callow system. The cells are constructed in the shape of cylindrical tanks, 24 inches in diameter by 6 feet 6 inches in height, the bottoms of which are formed by the porous medium. The feed enters near the top and near the center of the cylinder D through an adjustable disc E, while the tailings leave the machine through a center hole F in the porous medium. The goose neck G, which extends up above the porous bottom, is for discharging the tailings; it also controls the height of pulp-level in the cell A. Sands that are too heavy to be carried up the goose neck may be drawn off through the pipe K. Through the pipe P, air under pressure enters the chamber C, and is injected into the pulp through a carborundum disc (canvas may also be used). The concentrate froth overflows around the circumference of the cell into the launder K.

It is evident that this cell would be limited in capacity on account of its round shape. If a large unit were built it would be bulky and also the distance the froth would travel to leave the machine would be too great for good work.

<sup>22</sup>"The History of Flotation at Inspiration," Rudolf Gahl, *Bull. A. I. M. E.*, Sept., 1916.

<sup>12</sup>This form of bottom was also first used by Callow and is the standard bottom used at present.

## IMPROVEMENT ON FLINNE TOWNE MACHINE

With this apparatus as a suggestion Messrs. Cole<sup>b</sup> and Bergman have designed an apparatus which is an

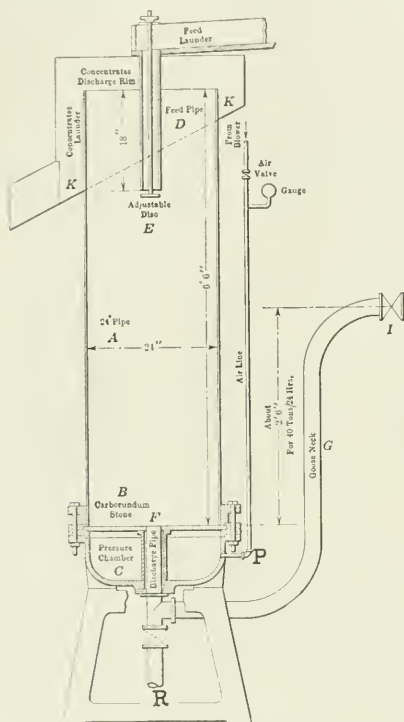


FIG. 8. FLINNE TOWNE MACHINE

Improvement on the Flinne Towne machine. It, however, embodies many of the principles of the latter.

(To be continued.)

## Gas Chemists of Bureau of Mines Transferred to War Department

By order of President Wilson dated June 29, 1918, all of the activities of the Government concerned with the investigation and manufacture of poison gas for war purposes were transferred on July 1 to the control of the War Department. The research work on this subject was begun some months ago under the direction of the Bureau of Mines which established a chemical section at the American University, Washington. In making the transfer, President Wilson acknowledges the excellent work done by the Bureau in establishing and maintaining this work, but states that a more efficient organization can be effected by concentrating all of the facilities for offensive and defensive gas operations under the newly organized Division of Gas Warfare. The gas experiment work is now under the direction of Major General William L. Sibert who was recently returned from France where he commanded the First Division of the regular army.

## Bibliography of Electric Furnace for Brass Melting

IN METALLURGICAL AND CHEMICAL ENGINEERING, June 1, 1918, page 533, H. W. Gillett and A. E. Rhoads presented an article on a rocking electric brass furnace. Owing to lack of space at that time the following bibliography was omitted:

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## After-the-War Program of Vickers (Ltd.)

This firm is now establishing a market for sewing machines to be produced at one gun factory by the 1700 general service machine tools there available. A study of the proper reduction of waste has led to the installation of a plant for making wooden ware, which is to be rapidly expanded, and which will get its raw material from their shipyards even after they have been converted from the making of war ships to those for the mercantile marine. Another plant is to make automobile accessories. Vickers have also acquired the Bosche Magneto Works and partial control of the British Westinghouse Co.

<sup>b</sup>"The Advent of Flotation in the Clifton-Morenci District, Arizona." By David Cole. *Bull. A. I. M. E.*, Sept., 1916.

## The Role of Complex Salts as Electrolytes in Plating and Refining Baths\*

BY REGINALD S. DEAN AND MING YI CHANG

IT HAS long been known that complex salts gave smoother and more adherent deposits than could be obtained from equivalent concentrations of simple salts. The reason for this as commonly given is that the deposit is the result of a secondary reaction, the metal being precipitated rather chemically than electrolytically; e.g., the silver from a potassium-silver cyanide solution is assumed to be deposited by the preliminary discharge of the potassium ion and subsequent deposition of the silver by the potassium formed. This explanation seems a bit forced since there is no *a priori* reason why the silver deposited by chemical action of the alkali metals should be

concentration of the ion being discharged, or, more generally, the greater the potential difference between the deposit and the bath the more nearly amorphous will be the deposit. He says:

"It is well known that silver and copper precipitate in a more nearly amorphous form from potassium cyanide solutions than from nitrate solutions. It is not a case of secondary deposition giving a good deposit as has sometimes been assumed because the decomposition voltages of the copper and silver cyanide solutions used in plating are lower than the decomposition voltage of the corresponding pure cyanide solution. As we can get a plating deposit of silver from a silver nitrate solution under suitable conditions it is obvious that there is no fundamental difference introduced by the formation of a complex salt. So far as the facts are known they can be formulated in the statement that the deposit is more finely crystalline the greater the potential difference between the metal and the solution."

The experimental evidence favors this theory for simple salts, at least so far as moderately large ion concentrations are concerned, as is shown by the accompanying pictures (Figs. 2, 3 and 4) of the

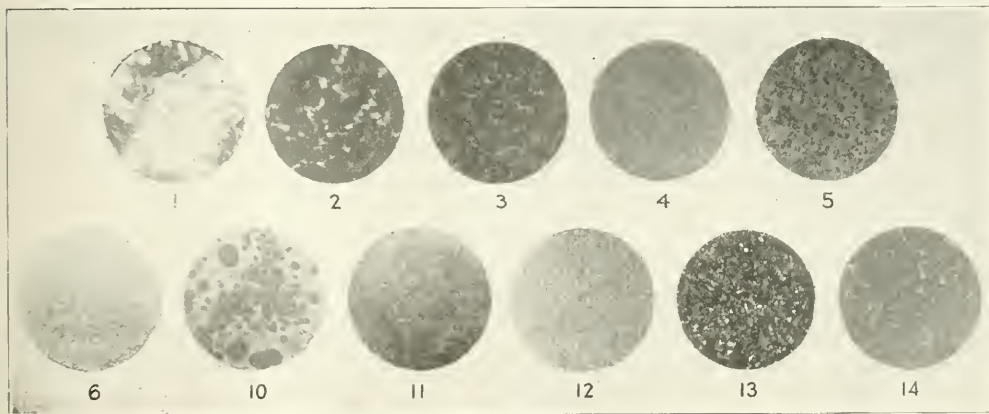


Fig. 1—Silver deposit on magnesium;  $\times 60$  diameters

Fig. 2—Silver deposit from  $\frac{N}{100}$   $AgNO_3$ ;  $\times 60$  diameters.

Fig. 3—Silver deposit from  $\frac{N}{100}$   $AgNO_3$ ;  $\times 60$  diameters.

Fig. 4—Silver deposit from  $\frac{N}{100}$   $AgNO_3$ ;  $\times 60$  diameters.

Fig. 5—Silver deposit from  $Ag_2O$ ;  $\times 60$  diameters

Fig. 6—Silver deposit from a solution made by dissolving  $AgCl$  in  $KCN$  ( $AgCl + 2KCN = KAg(CN)_2 + KCl$ );  $\times 60$  diameters.

Fig. 10—Copper deposit from copper tartrate;  $\times 60$  diameters.

Fig. 11—Copper deposit from copper tartrate with addition of  $Na_2SO_4$ ;  $\times 60$  diameters.

Fig. 12—Copper deposit from copper tartrate with addition of  $Al_2(SO_4)_3$ ;  $\times 60$  diameters.

Fig. 13—Cadmium deposit from 0.1 molar  $CdCl_2$ ;  $\times 60$  diameters.

Fig. 14—Cadmium deposit from 1.0 molar  $CdCl_2$  with addition of  $NaCl$ ;  $\times 60$  diameters.

more smooth and adherent than the electrolytic deposit. Certainly the chemical deposit obtained by the replacement with iron is neither smooth nor adherent and that obtained with magnesium is even more coarsely crystalline, as shown by the photomicrograph in Fig. 1.

Glaser<sup>1</sup> has suggested that the beneficial action of the complex tartrates may be due in part to the reducing action of compounds formed from them during electrolysis. Bancroft thinks that this can possibly be extended to the effect of complex cyanides. Good deposits, however, may be obtained from many complex solutions which show no reducing action; e.g., the silver-ammonia complexes.

A third very interesting theory has been proposed by Bancroft.<sup>2</sup> It is based upon the fact that the crystallinity of a deposit decreases with decreasing

deposits obtained from hundredth, thousandth and ten-thousandth-normal solutions of silver nitrate. Whether this evidence can be extrapolated to solutions containing so little silver ion as the complex cyanides can not be definitely stated. An attempt to determine this experimentally was made, using violently stirred suspensions of silver oxide, chromate, chloride, thiocyanate and sulphide. In this way concentrations of silver ion comparable to that in the argenticyanide were maintained without the additional influence of a complex salt. The anode used was pure silver foil while the cathode was a highly polished copper strip. The current used was about 0.05 ampere and the voltage about 2.6; the electrode area was 2.5 square centimeters.

The deposit obtained from the silver oxide is shown in Fig. 5, and is seen to be somewhat more crystalline than that obtained from ten-thousandth-normal silver nitrate which is about what would be expected from the solubility of the silver oxide. We found it im-

\*Contribution from the Metallurgy Laboratory of the University of Pittsburgh. Experimental work from the thesis of M. Y. Chang.

<sup>1</sup>Glaser Zeit. f. Elektrochemie 7, 386 (1900)

<sup>2</sup>W. D. Bancroft, Journ. Phys. Chem. 9, 290 (1905)



possible to obtain a deposit from silver chromate or any of the less soluble salts even after the addition of enough potassium nitrate to make a 10 per cent solution. If, however, cyanide was added to any of these suspensions a solution was obtained which must obviously have been less concentrated in silver ion than

but the  $K^+$  ion, and the behavior of the latter is exactly what would be expected since the concentration of  $K^+$  ion is much larger in  $KAg(CN)_2$  than in a corresponding KCN solution, the extreme weight of the anion in the complex salt causing practically complete ionization.

Experiments to determine if the deposition of silver from a cyanide solution took place at the voltage which would be expected from the concentration of potassium ion were made. The apparatus employed was novel and will be described in some detail. It was essentially an adaptation of the Leeds and Northrup transition point instrument for the determination of decomposition voltage. The voltage was read on the difference couple galvanometer scale, the galvanometer being shunted directly across the cell with a graphite resistance in series. The graphite resistance is essential, and to insure constancy is best made in the manner developed by V. H. Gottschalk and R. S. Dean especially for this kind of work at the Missouri School of Mines. A plate of frosted glass or unglazed porcelain serves as a base and the lead-pencil line is drawn across it, the contacts being made with tin foil and screw clamps, and the whole placed in a dessicator over phosphorus pentoxide and the wires led in through a stopper. The use of a dessicator is much more satisfactory for preventing the absorption of water than any kind of wax or lacquer. The resistance necessary depends on the cell and electrodes used, but should be several megohms. In order to get readings which can be traced it is best to set the beam of light as far to the left as possible and then place about three volts across the galvanometer circuit and regulate the graphite resistance so as to get a readable value. The current is read by means of the thermocouple galvanometer and a 0.001-ohm shunt, the voltage across the shunt being balanced by the drum potentiometer. In the use of the apparatus

the current is gradually increased by means of a potentiometer and the voltage and current followed by the tracing pen. The connections and general construction of the apparatus are made clear by the photograph and

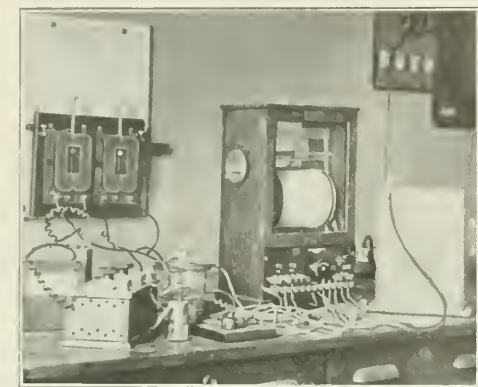


FIG. 7.—LEEDS AND NORTHROP TRANSITION-POINT APPARATUS SET UP FOR THE DETERMINATION OF DECOMPOSITION VOLTAGE

the suspension, but which, nevertheless, gave a good silver deposit (see Fig. 6).

It is not particularly surprising from the experimental point of view that no deposit is obtained from solutions so dilute in silver ion as silver chloride, since the decomposition voltage increases with the dilution, and at dilutions as great as that of insoluble salts exceeds the hydrogen decomposition point and hence the current efficiency drops practically to zero. But why do we obtain a deposit from a cyanide solution which certainly contains less silver ion than the chloride solution, since we have no reason to believe that the decomposition point of an ion depends on anything but the concentration of that ion? These facts may be explained by the secondary deposition theory since the deposition in that case is due to the discharge of the  $K^+$  ion, which, being present in high concentrations, may

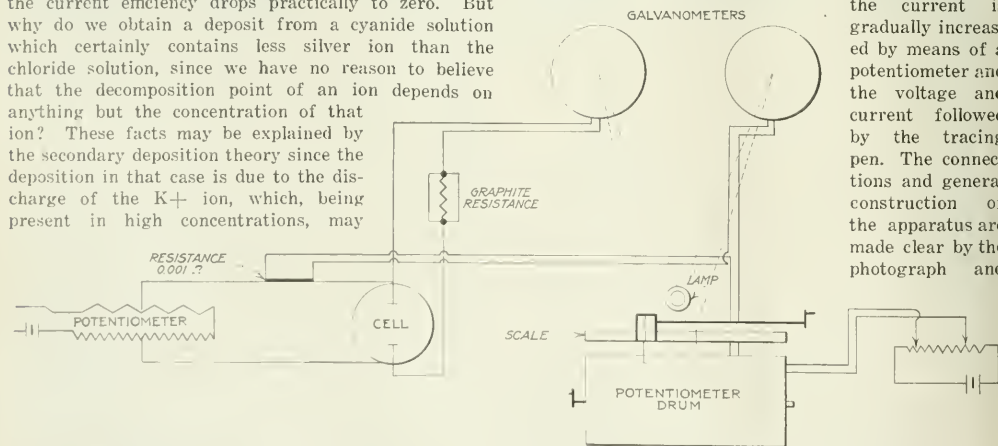


FIG. 8.—DIAGRAM OF LEEDS AND NORTHROP TRANSITION-POINT APPARATUS ARRANGED FOR DECOMPOSITION VOLTAGES

readily reach its decomposition voltage long before the extremely dilute silver ion. Bancroft notes that the decomposition cannot be secondary, since the  $KAg(CN)_2$  has a lower decomposition voltage than the corresponding KCN solution. This argument, however, is not valid since it is not the  $Ag^+$  ion, which is discharged,

diagram. (Figs. 7 and 8.) The curves obtained with this apparatus from tenth-normal silver nitrate, 0.275-normal potassium nitrate, and a potassium-silver cyanide solution 0.25-normal with respect to potassium and 0.1-normal with respect to silver are shown in Fig. 9. The potassium nitrate

solution was made of such strength that, assuming 75 per cent ionization for  $\text{KNO}_3$  and  $\text{KCN}$  and 100 per cent for  $\text{KAg}(\text{CN})_2$ , the concentration of potassium ion in the two solutions would be the same. The results show that the decomposition voltage of the  $\text{KAg}(\text{CN})_2$  is practically what would be expected from the concentration of potassium ion, and bears no relation to either the total concentration of silver or concentration of silver ion. This proves that the deposition of silver from complex cyanide solutions is due to the discharge of potassium ion.

There is little question then that the deposition is secondary but this explanation fails to say why we cannot accomplish the same result with a silver chloride suspension containing potassium nitrate. The reason is evidently that in so dilute a solution of silver as the chloride, the potassium liberated decomposes only water instead of silver nitrate, due to mass action, while in the case of the argenticyanide the un-ionized silver which is present in relatively large concentrations

Admitting, however, that the deposit is secondary when obtained from most complex solutions we are still uninformed as to why secondary deposition gives a smooth deposit. As previously noted, magnesium gives a very crystalline deposit so we must look elsewhere than the mere deposition by a metal of high solution-tension for an explanation of the phenomena. The presence of large crystals is due to the tendency of crystals to grow; i.e., in the case of silver the next atom of silver tends to deposit on the silver already deposited. Now in secondary deposition there is no opportunity for crystal growth since an atom of alkali metal is deposited and before it has an opportunity to grow is dissolved with the formation of silver; and since there is no other alkali metal present the next atom is deposited at random and in this way a smooth deposit is obtained. The failure to obtain a smooth deposit with magnesium is readily explained on this basis since the first bit of silver deposited forms with the still exposed magnesium a small cell in which the magnesium goes into solution on the one hand and the silver is deposited on the other.

In order to test these conclusions a solution of copper tartrate in tartaric acid was prepared by adding tartaric acid to copper acetate. The solution so obtained was about tenth-normal with respect to copper but was evidently quite low in copper ion content since the copper tartrate did not precipitate. A solution of this kind was electrolyzed using copper anode and cathode, the potential across the cell being maintained at three volts. Despite the very low concentration of copper ion the deposit obtained was very crystalline which confirms our conclusion that the presence of a metal of lower solution-tension is essential to the formation of an amorphous deposit. If now sodium sulphate was added to the copper tartrate solution and the electrolysis carried on under identical conditions, a quite smooth deposit is obtained. The addition of aluminium sulphate produces a similar result. These deposits are shown in Figs. 10, 11 and 12.

Still further results were obtained with cadmium solutions using a molar solution of cadmium chloride with the addition of  $\text{NaCl}$  and a tenth-molar solution without the addition of  $\text{NaCl}$ . These two solutions contain very nearly the same concentration of cadmium ion but the deposit from the solution containing the  $\text{NaCl}$  was markedly less crystalline. These deposits are shown in Figs. 13 and 14.

We may then define the conditions under which a complex solution will give an amorphous or nearly amorphous deposit.

(1) The presence of another metal than the one being deposited, which other metal must have a notably lower solution-tension than the one being deposited.

(2) A sufficiently complex salt that the concentration of the ion being deposited will be so low that its discharge voltage will be above that of the secondary metal.

We are indebted to Prof. V. H. Gottschalk of the Missouri School of Mines and Metallurgy for the suggestion of trying Bancroft's theory by the use of suspensions of insoluble salts.

The experiments quoted above are from the thesis of Mr. M. Y. Chang at the University of Pittsburgh.

Pittsburgh, Pa.

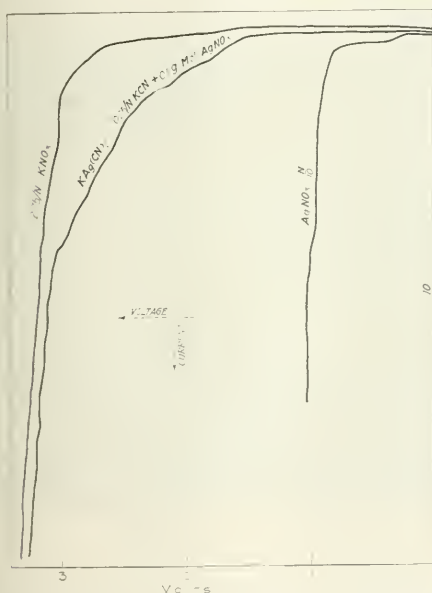


FIG. 9.—DIAGRAM OF DECOMPOSITION VOLTAGE-CURRENT CURVES OBTAINED WITH LEEDS AND NORTHROP TRANSITION-POINT APPARATUS

is decomposed by the potassium. In other words the secondary reaction is not an ionic one but may be represented by the equation



or possibly



It follows that the real purpose of a complex solution is to furnish a concentrated solution of the metal, but a dilute solution of its ion; further the complex salt must have so little heavy-metal ion that the discharge of the alkali-metal ion will take place first.

## Development of an Electric Furnace for Annealing Treatment and Forging of Steel\*

BY WIRT S. SCOTT

**E**XPERIMENTAL work by the Westinghouse Electric & Manufacturing Co. on register-type furnaces for forging has continued through several years. Our first investigation was with a granular graphite resistor bed 9 inches wide, 8 inches deep, by 36 inches long, for heating a furnace having an opening 36 inches wide, 24 inches deep by 10 inches high. Other resistor materials consisting of granular graphite, coke, charcoal, and finally these materials in various combinations, also in combination with carbon blocks, were given exhaustive tests, always with the same general result. It is sometimes of equal importance to know the reasons for failure as for success; hence it should be of interest to know the reasons for discarding all of the above resistor materials as being unsuitable for an electric forging furnace.

### LIMITATIONS OF CARBON RESISTORS

To secure even moderately successful results, it was found that the resistor material must be of the purest carbon or graphite. It is quite difficult to obtain a supply sufficient for operating furnaces.

If there is any slag or ashes left from the combustion of the resistor, it remains in the bed, so that the relative proportion of such material is gradually increasing with time, causing an increase in the resistance of the furnace. If the slag or ash is fusible at the temperature of the resistor bed, a clinker will be formed which very rapidly extends through the granular mass, resulting in a rapid increase in resistance and consequent failure to heat.

When the furnace was maintained for a considerable length of time at sufficiently high temperature to turn out heated steel at 1800 deg. F., we found that the temperature in the bottom of the resistor bed exceeded the safe limits of refractory materials. With a temperature of 1800 deg. F. on the surface of the bed, it was found that the temperature at the bottom was approximately 3600 deg. F. This great temperature difference is due to the electrical characteristics of carbon in that it has a large negative temperature resistance coefficient, that is to say, as the temperature increases, the resistance decreases. It is evident that the carbon in the bottom or at the center of the bed will operate at higher temperatures than the surface, which has an opportunity to radiate its heat to the surrounding air and chamber. An increase in temperature at any given part, lowers the resistance through that part, which in turn causes more current to flow, and so on, the temperature gradually increasing with the current. Conditions tend to become stable at any very high temperature, but greatly in excess of that which may be safely withstood by any refractory material now available.

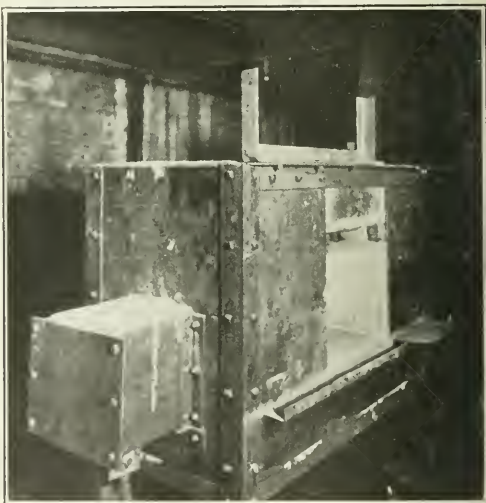
In heating a piece of work in an ordinary fuel-fired furnace, heat is transferred to the work by conduction from the hot gases and by radiation from the walls. The walls are maintained at a temperature higher than

that desired at the work because they are continuously swept by the hot gases. In an electric furnace we do not have this action to heat all of the surface uniformly.

If heat is generated only on the floor of the hearth, the side-walls and roof must obtain their heat by direct radiation. If cold pieces of metal are laid closely over the surface of the resistor hearth, they will interfere with the radiation of the heat to the walls and roof directly in proportion to the amount of hearth surface they cover. This would mean that the work would be heated from the under side only, and instead of receiving heat from the walls and roof, it would be giving off heat, thereby always having a great difference in the temperature in the two opposite sides. In order to heat the upper surface to a sufficiently high temperature, the lower surface must be overheated.

### PROPERTIES OF SILICON CARBIDE

During the latter part of 1916, we began our experiments in using carbide as a resistance material. A study of the chemical and physical properties of silicon



ELECTRIC RESISTANCE ANNEALING FURNACE

carbide led us to believe that it possessed desirable qualities essential to a suitable resistor for an electric forging furnace, but also indicated that there were many difficulties to be overcome which were real problems in themselves.

The temperature of formation of this resistor is 1950 deg. C. (3542 deg. F.). The temperature of decomposition is 2220 deg. C. or 4018 deg. F. There is no oxidation of this material in pure oxygen at 1000 deg. C. (1800 deg. F.). From 1500 deg. to 1800 deg. C. (2732 deg. F. to 3272 deg. F.) oxidation is very much retarded by the fused silica coating. Neutral or reducing gases, such as carbon monoxide, nitrogen and hydrogen have little or no action.

The hardness is between the ruby and the diamond. The specific gravity is 3.12 to 3.20. Based on a specific gravity of 3.20 the weight of the solid block without pores is 199.7 lb. per cubic foot or 0.116 lb. per cu. in.

\*A paper presented before the Assn. of Iron and Steel Electrical Engineers, Pittsburgh, Apr. 20, 1918.



In order to adapt silicon carbide to its various uses the tensile strength of the bonded articles may be made to vary between wide limits. In ceramic-bonded articles where the bond does not introduce objectionable physical or chemical properties, a tensile strength of 1400 lb. per square inch may be attained. A sacrifice of resistance to heat changes and chemical actions affecting ceramic articles must be expected with high tensile strength.

The resistor is a conductor of the second class. At ordinary temperature its conductivity is very low, being several times less than carbon. With increase of temperature its conductivity increases very rapidly, as it has a large negative temperature resistance coefficient.

The resistivity of the bricks varies with differences in porosity and chemical composition. However, it is interesting to note that at temperatures above 1800 deg. F. the resistivities have approximately the same value. A general idea of the variation of the resistance will be obtained from the following:

| Deg. F. | Ohms Per Cu. Cm. |
|---------|------------------|
| 75      | 50               |
| 1000    | 18               |
| 1800    | 3.7              |
| 2550    | 0.65             |

#### EXCELLENT QUALITIES OF SILICON CARBIDE AS A RESISTOR

From a resumé of the above, it may be seen that this resistor material possesses the following excellent qualities: (1) The temperature of decomposition is above 4000 deg. F., which is approximately 1500 deg. higher than the hottest temperature required at the surface of the resistor. Due to the construction of furnace employed, the atmosphere in the furnace chamber is non-oxidizing, and under these conditions the resistor is non-consuming. (2) It may be molded in block form, allowing the heating element to be placed in any desirable position around the heating chamber. (3) Due to its high tensile strength, the roof of the heating chamber, as well as the hearth may be made out of these resistor blocks. (4) The fact that it has a large negative temperature resistance coefficient may be utilized in the control of the furnace temperature by controlling the current input to this resistor material.

#### DESIGN AND TEST OF FIRST EXPERIMENTAL FURNACES

The first complete furnace of this type which we built and which gave promise of success had an outside dimension 41 in. wide across the front, 27 in. deep and 48 in. high. It was designed with two working chambers 7 in. long by 5 in. high, for the heating of 50 lb. of steel per hour to 1800 deg. in each chamber, or a total of 100 lb. per hour for the furnace. The resistors consisted of blocks having a cross section of 4½ in. by 2½ in. passing above and below the working chamber. The resistors terminated in electrode chimneys filled with granular graphite, into which steel terminal plates extended, for external connections.

Owing to the high resistance of this type of furnace when cold, and due to the length of resistors used, a starting voltage of 220 volts was required, which was cut down in a few minutes time to 110 volts, and then gradually reduced until 60 volts was reached, which maintained the proper temperature.

The time required to bring the furnace up to an operating temperature of 1800 deg. F. was eight hours,

starting with the furnace cold. Owing to the great heat reserve capacity of the furnace, the time required in successive heatings was greatly reduced, depending upon the length of time the furnace was out of operation. In order to have the furnace available for immediate use, sufficient current was maintained on the furnace during the night to supply the radiation losses. On a 20-hour continuous forging test the average input during this test was about 18 kw. or 300 amperes at 60 volts. The charge during this test consisted of approximately four pieces of steel weighing six pounds total, each piece requiring an average of three heats, one from cold to 1800 deg. F., the other two from about 900 deg. F. to a final temperature of 1800 deg. F. The hourly output averaged 20 pounds heated from 70 deg. to 1800 deg. F. and 40 pounds from 900 deg. to 1800 deg. F.

No special attention was given to the thermal insulation of the furnace since that was of secondary importance, and a matter which could be taken care of at a later date, once we secured a suitable construction. Notwithstanding the light insulation that was used, a furnace efficiency of 41 per cent was maintained. The furnace ultimately proved unsatisfactory due to unequal heating of the two chambers.

The results of the tests proved conclusively that a temperature of 1800 deg. F. could be obtained and maintained for an indefinite period so far as the resistor material was concerned. Hand control was used entirely in the operation of this furnace, in conjunction with a circuit breaker for tripping the circuit should the current increase beyond a safe operating value.

#### DESIGN AND TEST OF SECOND EXPERIMENTAL FURNACE

The second complete furnace had an overall dimension of 46 in. wide, 38 in. deep by 48 in. high, inclusive of an iron stand 12 in. high. The radiating surface was approximately 81 sq.ft. The resistor consisted of two blocks 2½ by 4½ in. cross-section by 9 in. in length, connected in parallel, one over the heating chamber, and one underneath 2½ in. apart, forming a heating chamber 7 in. wide, 11 in. deep by 2½ in. high. The resistors were surrounded and imbedded in a refractory lining made up principally of a crucible clay and a graphite mixture. Surrounding this extremely hot area, silica bricks were used, backed up by ordinary fire bricks.

Electrode chimneys or wells were used very much the same as with the first furnace. The electrodes consisted of granular graphite and an amorphous carbon rod 4 in. square by 20 in. long embedded in each electrode well, and extending upward from near the steel terminal plate at the bottom of each well to the ends of the two resistors. The granular graphite insures electrical contact between the resistor blocks and the carbon block, and between the carbon block and the terminal plate. A cool terminal is thus obtained. The heat insulation on the outside of the furnace consisted of 4½ in. of high-grade insulating brick all around, except opposite the electrode walls and around the door. Thin sheet-steel held in place by angle-iron and tie-rods clamped the insulating bricks together.

The starting voltage on this furnace was 75 volts, and the time required to raise the temperature of the heating chamber to a forging temperature of 1800 deg. F. was two hours. The power required at full load was 10 kw. or approximately 300 amperes at 33 volts. At no load,

a consumption of 5 kw. or 200 amperes at 25 volts obtained. This corresponds to an efficiency of 50 per cent.

The longest continuous run extended over a period of 15 days, or 370 hours, the furnace being maintained continuously at a forging temperature of 1800 deg. F. After these tests, an examination of the resistors was made, but no perceptible effect due to heating could be determined.

The control equipment consisted of a 110-volt transformer with knife switches for obtaining starting voltage, and interlocked magnet switches, push-button-operated, for obtaining the required running voltage. A circuit breaker was used as in the first case for protecting the furnace against an increase in current above the operating value.

The first furnace to be placed in continuous operation under actual shop conditions was made early in 1917. This furnace, a duplicate of the one last described, was installed in the tool-forging shop of the Westinghouse Electric & Manufacturing Company, and while it was considered that the furnace was still in its experimental stages, it was essential that we gain the experience of knowing how it would stand up under regular shop conditions.

Several failures of the furnace were recorded, but in each case the failure was due to the improper functioning of the control equipment which we were developing and experimenting with at that time. This furnace has been in operation for a period of one year, with highly encouraging results. Many runs have been made of continuous operation for periods of 400 and 500 hours, forging high-speed steel to 1850 deg. F. and drop-forging at 2200 deg. F. without any records of resistor failure, or any perceptible deterioration in the resistor due to the high operating temperature. One run of 500 hours was made at a temperature of 2650 deg. F. without experiencing any difficulty whatever.

For high-speed steel work, as it was found advisable to preheat the steel before placing it in the heating chamber, a preheating chamber was constructed under the heating chamber, consisting of an opening in the front of the furnace just below the lower resistor, into which the tools could be placed for preheating to eliminate strains that otherwise would be set up in the steel when placed in the furnace.

Another furnace has been built and placed in operation at our works, having a heating chamber 18 inches wide, 12 inches deep and 4½ inches high. The capacity

of this furnace is 20 kw., the starting voltage 220, and the running voltage 70. The efficiency is 60 per cent. This furnace is designed to operate on steel drop-forging requiring a temperature of 2300 deg. F.

#### DEVELOPMENT OF AUTOMATIC CONTROL EQUIPMENT

The control equipment at the present time is not completely automatic. That is to say, the furnace is not automatically brought up to the required temperature, but once the required temperature is obtained, then the control equipment will maintain that temperature within certain limits. Interlocked knife switches are used for connecting to the starting taps on the transformer.

As the furnace increases in temperature it is necessary to step down to lower voltages. The lower voltage taps are controlled by means of magnet switches operating over a relatively small percentage of the voltage range in order to obtain close temperature regulation.

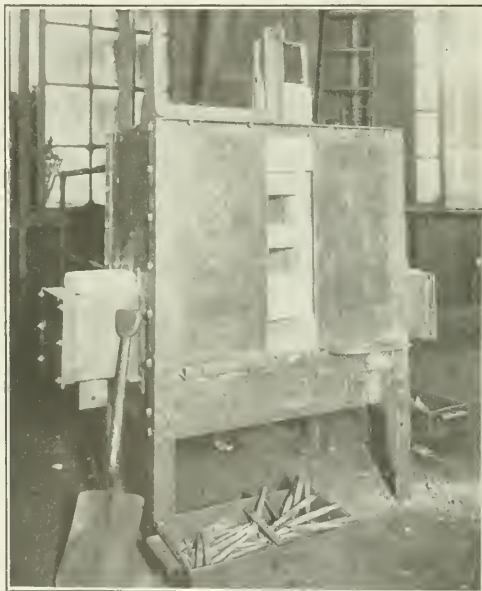
The control equipment thus far developed is semi-automatic in its action, and may be used with entire satisfaction where the operator has a proper appreciation of the functioning of the control equipments. However, it is our intention ultimately to develop a complete automatic control equipment, which we hope to have perfected at an early date.

The general type of the furnace such as we have developed has a very wide application, but our ex-

periments thus far have been largely confined to forging, vitreous enameling, and for the reheating of glassware. A special furnace has been constructed and is successfully operated for the forming of lamp chimneys.

#### DISADVANTAGES OF FUEL-FIRED FURNACES FOR FORGING

Forging requires an operating temperature of from 1800 deg. to 2300 deg. F., depending upon the kind of steel used. One great difficulty with a fuel-fired furnace is not in the ability to obtain a sufficiently high heat, but in uneven heating. It is almost impossible to obtain uniform temperature throughout the entire chambers; consequently when the furnace is operated on a production basis, with several pieces being heated at one time, some of the pieces of work will be much hotter than others. The pieces in the hottest portion in all probability will heat much too rapidly, with the result that either the corners of the tools are burned before the material is heated clear through, or if it is removed before the surface burns, the center has not reached a suffi-



ELECTRIC RESISTANCE ANNEALING FURNACE

ciently high temperature. In this case the soft outside will yield much more readily than the hard inside, with the result that the outer particles will be torn asunder while the inside will be sound. The loss through oxidation takes place while the work is being heated in a fuel-fired furnace and also after it has been withdrawn and is being forged. The oxidation in the furnace is by far the larger of the two.

Annealing or softening is accomplished by heating steel to a red heat ranging from 1300 deg. to 1600 deg. F., depending upon the grade of steel, and then cooling it slowly. If the temperature is carried too high, it may leave the steel actually harder than the proper heat would leave it, besides running the risk of forming a scale. If scale is raised on a piece of steel, this scale will be a granular oxide of iron, and may spoil the tools used to cut it, sometimes changing the structure of the steel, making it brittle and causing it to crack in hardening. The effect of heat on steel may be noted by taking a bar of steel nicked in 10 or 12 places about  $\frac{1}{8}$  inch apart, heating it in a fuel-fired furnace until the end is up to a good white heat, and then plunging it into cold water. In breaking off the pieces at each nick, it will be seen that characteristic changes have taken place in the steel. The end of the rod which had been over-heated will be very open or crystalline in structure, the succeeding pieces becoming closer and closer in grain until one piece is formed possessing a close, even grain, the structure desired.

For every variation in the temperature there is a variation in grain of the steel. The effect of too high a heat is to open the grain, to make the steel coarse. The effect of irregular heat is to cause irregular grain, irregular strains and cracks in the steel.

#### ADVANTAGES OF ELECTRIC FORGING FURNACE

The furnace described offers an ideal solution for the conditions as above outlined, because:

(a) Uniform temperature is obtained in all parts of the heating chambers.

(b) The temperature found to produce the most satisfactory results may be obtained and maintained indefinitely.

(c) A neutral atmosphere is obtained in the furnace chamber, thereby eliminating the major part of the oxidation of the steel.

For a given class of work subjected to a given heating operation the following conditions must apply.

1. The rate at which the work is heated is capable of infinite variation, but there must be some best sequence of heating.

2. The temperature difference between the heating medium and the work may be almost any value, but there must be some best value.

3. The maximum temperature to which the work is heated may be within fairly wide limits, but there must be some most satisfactory temperature to which each grade of steel should be heated.

An electric furnace permits of doing such experimental work as will exactly determine these factors; and, once they have been determined, it permits an operator to duplicate these results in operation: the ultimate feature in which we are interested.

Pittsburgh, Pa.

## Société Coopérative for Belgium

In view of the critical situation which will result for Belgium through the disasters caused by the depredations of the enemy, his removing of tools, raw materials, manufactured products, etc., there has been created, with the coöperation of and under the control of the Belgian State, an organization having for its object the economical reconstruction of Belgium, entitled "Comptoir National Pour La Reprise de l'Activité Economique en Belgique (Société Coopérative).

This organization, in helping industry and trade, by enabling them to purchase the tools and all necessary raw materials, will not only reconstruct the economic situation of Belgium, but will put an end to the sufferings of the working classes by enabling them to start working in the reconstructed shops. All materials required for reconstruction are of interest to this organization, including materials for construction of buildings, leathers, textiles, farming implements, chemical products, wood machines, electrical materials, optical instruments, motor cars, vans, wagons, oils and greases of all kinds, refractory materials, etc. American manufacturers who have such materials to offer for export, either now or after the war, are requested to send catalogs and tariffs in triplicate.

## Wood Alcohol for Motor Purposes

According to Consul General Albert Halstead, Stockholm, the war has naturally tended to cause neutral nations that are unable to procure their usual supplies of manufactured and other products to start to manufacture for the home market, and often to make substitutes. As a result these markets for American manufactures are certain to be found more competitive in many lines after the war, while in others to be unprofitable because of the success of domestic industry. However, a business man expressed the opinion the other day that perhaps 60 per cent of the newly established industries in Sweden would be unable to withstand foreign competition when it is resumed. From Germany systematic dumping was looked for, plans for which have already been made.

The impossibility of securing gasoline had almost driven automobiles from the streets of Stockholm. Recently, however, some taxicabs have reappeared which use wood alcohol instead of gasoline.

The newspapers of February 15 announced the formation of the Sulphite Mills Sales Co., with a capital of from \$53,600 to \$160,800 and representing 13 mills. Two are already using their waste lye for the manufacture of spirits, a number are soon to begin such operations, and others are planned. The production of the completed mills is said to amount to 15,000,000 liters (3,962,660 gallons) of 100 per cent pure alcohol a year. When all the mills are operated, their total capacity is calculated at 25,000,000 liters (6,604,440 gallons), and if all the Swedish sulphite mills were to produce spirits, the aggregate capacity would, it is said, reach 40,000,000 liters (10,567,100 gallons) annually. Continued Government assistance is expected for this industry.



# Destructive Distillation of Oil Shales

Description of Products, Influence of Sulphur, Oxygen and Nitrogen Content—Commercial Possibilities

By JAC C. MORRELL AND GUSTAV EGLOFF

THE oil shale used in the present experiment was derived from the Green River formation, which belongs to the Eocene period consisting mainly of shale. The outcrop which consists of a greyish-white color, but really shows bands of white to grey, was not selected for retorting samples, but those which showed a brownish to black appearance on the freshly broken surfaces. This shale was tough and showed no bedding planes, but they were developed by retorting. Plant structure was clearly noted in a number of the pieces which indicated its derivation, and when freshly broken gave the faintest odor of petroleum at times.

## EXPERIMENTAL METHOD

The first apparatus used for distilling the shale was a modification of that used by the United States Geological Survey. The permanent gases formed after being led through an ammonia scrubber were passed successively through a gas meter, a scrubber with 1.84 specific gravity sulphuric acid to remove unsaturated gases and another meter to record unabsorbed gases. The shale was broken up into pieces about three-fourths of an inch square, and a one-pound charge was introduced into the retort. The retort was slowly heated with a five Bunsen burner cluster until a dull-red heat was attained, and kept at this temperature for about four hours. The apparatus was then disconnected, the condensed liquids consisting of oil and water placed in a graduate and allowed to stand until a sharp line marked off the oil from the water and the quantity of each was then read off. The liquids were then placed in a separatory funnel, and allowed to stand for about twelve hours, a clean separation then being made. The water portion was added to the liquor (dilute sulphuric acid) from the ammonia scrubber and the ammonia determined by the Kjeldahl method. The oil was later subjected to a distillation analysis, and the various fractions further examined.

Further tests were made to determine solubility, ash, fixed carbon, and volatile matter.

The products resulting from the retorting of one pound of oil shale was not sufficient to make more than the following data in tables No. I and No. II:

TABLE I.

|                                 | Per Cent |
|---------------------------------|----------|
| Spent shale                     | 84.1     |
| Ash                             | 61.3     |
| Fixed carbon                    | 22.8     |
| Total volatile matter           | 38.7     |
| Oil                             | 7.49     |
| Water                           | 2.79     |
| Soluble in CS <sub>2</sub>      | 0.13     |
| Ammonia as sulphate of ammonium | 1.27     |

TABLE II.

Products Produced per Ton

|                     |              |
|---------------------|--------------|
| Oil                 | 20.3 gal.    |
| Total permanent gas | 1.947 cu.ft. |
| Sulphate of ammonia | 25.4 pounds  |

Since the retorting of one pound of oil shale did not give sufficient oil for close analytical results, a

larger charge was taken consisting of twelve pounds. For this purpose a horizontal retort was used of 8" diameter and length of 18" and made of double extra heavy lap welded steel tubing, which was built so as to conduct experiments later of retorting oil shale under vacuum and pressure, thereby varying the type product formed.

The method of retorting was by means of direct heating, with a thermometer inserted into a well in the body of the shale, and another thermometer in the vapor line of the retort. In table No. III, the still and the vapor-line temperature are shown. The last hour of retorting showed no liquid or vapors coming over, hence it was concluded that the oil had all been distilled out of the shale.

TABLE III.

First drop over water,  
136°C. Vapor temperature  
190°C. Still temperature

| Time       | Still Temperature<br>Deg. C. | Vapor Line Temperature<br>Deg. C. |                                     |
|------------|------------------------------|-----------------------------------|-------------------------------------|
| 10:55 a.m. | 20                           | 20                                |                                     |
| 11:25 a.m. | 103                          | 78                                |                                     |
| 11:55 a.m. | 213                          | 176                               |                                     |
| 12:25 p.m. | 315                          | 219                               |                                     |
| 1:55 p.m.  | 358                          | 266                               |                                     |
| 1:25 p.m.  | 365                          | 278                               | Odor of ammonia                     |
| 1:55 p.m.  | 370                          | 304                               |                                     |
| 2:25 p.m.  | 400                          | 323                               |                                     |
| 2:55 p.m.  | (a)                          | 348                               | Distinctly stronger odor of ammonia |
| 3:25 p.m.  | (a)                          | 350                               |                                     |
| 3:55 p.m.  | (a)                          | 355                               | Very strong odor of ammonia         |
| 4:25 p.m.  | (a)                          | 360                               |                                     |
| 5:55 p.m.  | (a)                          | 370                               |                                     |

Total retorting time 6 hours.

(a) Above 400°C. Still, reddish, white heat.

During the retorting of the shale, distillates of oil and water were collected every 100 cc. and the endeavor was made to distill at the rate of 100 cc. per hour. The gravity of the oil portion was taken, and the curious phenomenon was noted that the gravity of the oil in the first fraction was higher than the second and third and then the gravity increased again. The data indicates two maxima and a minimum in the values of the gravity of the various cuts. This is unusual, for the specific gravity of an oil upon distillation increases with increase of the boiling point. This phenomenon requires further investigation as it is certain that we have to deal with a different group of compounds from what is ordinarily known. This may be due to heterocyclic nitrogen compounds. Furthermore, during the retorting of the shale, droplets of liquid falling from the end of the condenser at times were insoluble in the oil layer and passed through the water layer to the bottom of the receiver. This was clear proof that we had to deal with oily material having specific gravity greater than water. There was only a trace of this material in comparison to the whole and not sufficient to test for; hence, to investigate this point a ton or more of shale would have to be retorted.

It was further noted that as the retorting proceeded the ammonia content of the water layer of the distilla-

tion cuts increased, which indicated that the yield of ammonia increases with temperature to a maximum, and then more than likely decreases.

The data is expressed in table No. IV.

TABLE IV. PRODUCTS OVER FROM RETORTING

| Sample     | Total e.e. Over Oil and Water | e.e. Oil Over | e.e. Water Over | Specific Gravity of Oil 15.5°C. | Beaumé Gravity of Oil 60°F. |
|------------|-------------------------------|---------------|-----------------|---------------------------------|-----------------------------|
| 1          | 100                           | 41.0          | 59.0            | 0.837                           | 37.3                        |
| 2          | 200                           | 63.0          | 37.0            | 0.826                           | 39.5                        |
| 3          | 300                           | 73.5          | 26.5            | 0.814                           | 41.9                        |
| 4          | 400                           | 87.0          | 13.0            | 0.887                           | 27.8                        |
| 5          | 500                           | 89.0          | 11.0            | 0.911                           | 23.8                        |
| 6          | 600                           | 83.0          | 17.0            | 0.944                           | 18.4                        |
| 7          | 676                           | 69.0          | 7.0             | 0.961                           | 15.7                        |
| Total e.e. | 676                           | 505.5         | 170.5           | 0.879                           | 29.3                        |

## Tests on Composite Samples of Recovered Oil

|                             |              |                        |
|-----------------------------|--------------|------------------------|
| Beaumé gravity              | 29.3         | Specific gravity 0.879 |
| Flash point below           | 95°F.        |                        |
| Viscosity Saybolt Universal | 100°F., 32.8 |                        |
| Color                       | 6            |                        |
| Cold test                   | -18°F.       |                        |

## DISTILLATION ANALYSIS OF RECOVERED OIL

The color of the recovered oil was a dark brownish red. Upon distillation, the analytical data is given in table No. V, the first 10 per cent of which showed a strong lemon color increasing in intensity until 40 per cent came over. The color of the distillates became darker, merging into wine red, with a black solid residuum in the flask, which showed a tendency toward cracking at a temperature of 360° C. The phenomenon of a liquid coming over during retorting which was partially insoluble in the shale oil and heavier than water has already been referred to. The same type reddish liquid came over in traces upon distilling the recovered oil which was insoluble in the lemon-colored distillate and fell to the bottom of the receiver. What type compound or compounds this represented, as to whether it was a nitrogen or sulphur compound with a low boiling point and high specific gravity, has not been ascertained as yet.

Table No. VI is the distillation data of the crude benzine cut of the recovered oil which was taken as the first 50 per cent over at a temperature of 435° F. and averaged Beaumé Gravity of 42.9.

In analyzing the data to arrive at a commercial motor fuel having an end point distillation of a present value of 410° F. and 57-58° Beaumé, we find that 85 per cent gives an end point of 405° F. but a Beaumé gravity of 45.9°. Although the volatility of the mixture will pass for a motor fuel, the gravity is very low; furthermore, the 85 per cent contains 36 per cent of substances combining with 1.84 sulphuric acid. Upon neutralizing the excess sulphuric acid with 6° Beaumé caustic soda and washing with water and drying over calcium chloride, a deep reddish black oil remained which would be the so-called motor fuel. For upon redistillation of the refined reddish black "gasoline cut", seventy per cent of distillate was a deep lemon color which upon standing developed a deep reddish-brown color with a Beaumé gravity of 47.3 which corresponds to a heavy naptha in petroleum technology. Much technical work will have to be carried on to refine the crude benzine from oil shale retorting so as to make a marketable motor fuel for internal combustion engines as at present constructed. To work up this oil into a marketable motor fuel is a much more difficult problem than the simple one now presented to the petroleum industry, due to the fact that this oil undoubtedly contains sul-

phur, nitrogen, highly unsaturated hydrocarbons of the terpene type, aromatic and phenolic compounds.

The higher boiling point cuts show beautiful lubricating oils of similar properties to those obtained from California and Russian oils. The oils must be highly naphthenic in character, and this point will be reported upon more fully in a later paper.

TABLE V. DISTILLATION ANALYSIS OF RECOVERED OIL

|                      |                   |              |
|----------------------|-------------------|--------------|
| Specific gravity     | 15.5°C.           | 0.8788       |
| Beaumé gravity       | 60°F.             | 29.3         |
| Per cent unsaturated |                   | 31.0         |
| First drop over      | 55°C.             | 131°F.       |
| Rate distillation    | 5 c.c. per minute | Engler Flask |

| Per cent Distilled Over | Degrees Cent. | Specific Gravity | Degrees Fahr. | Beaumé Gravity Standard | Bureau of Standard |
|-------------------------|---------------|------------------|---------------|-------------------------|--------------------|
| 5                       | 116           | 0.7365           | 240           | 60.1                    |                    |
| 10                      | 124           | 0.7411           | 254           | 58.9                    |                    |
| 15                      | 131           | 0.7621           | 268           | 53.7                    |                    |
| 20                      | 148           | 0.7839           | 300           | 48.6                    |                    |
| 25                      | 159           | 0.7982           | 326           | 45.4                    |                    |
| 30                      | 165           | 0.8092           | 331           | 43.0                    |                    |
| 35                      | 184           | 0.8226           | 364           | 40.2                    |                    |
| 40                      | 198           | 0.8358           | 390           | 37.5                    |                    |
| 45                      | 209           | 0.8469           | 410           | 35.3                    |                    |
| 50                      | 223           | 0.8584           | 435           | 33.1                    |                    |
| 55                      | 234           | 0.8701           | 454           | 30.9                    |                    |
| 60                      | 251           | 0.8822           | 486           | 28.7                    |                    |
| 65                      | 265           | 0.8951           | 511           | 26.4                    |                    |
| 70                      | 278           | 0.9091           | 534           | 24.0                    |                    |
| 75                      | 303           | 0.9244           | 579           | 20.8                    |                    |
| 80                      | 332           | 0.9472           | 630           | 17.8                    |                    |
| 85                      | 357           | 0.9635           | 675           | 15.3                    |                    |
| 90                      | 360           | 0.9804           | 681           | 12.8                    |                    |
| 8.5 residuum            |               | Solid            |               |                         | Solid              |

Distillation loss 1.5 percent.

TABLE VI. REDISTILLATION OF MOTOR FUEL CUT OF RECOVERED OIL

|                    |         |          |
|--------------------|---------|----------|
| Specific gravity   | 15.5°C. | 0.8097   |
| Beaumé gravity     | 60°F.   | 42.9     |
| First drop over    | 146°F.  | 63.5°C.  |
| End point          | 501°F.  | 207°C.   |
| Distillation range | 355°F.  | 178.5°C. |

| Per Cent Distilled Over | Degrees Cent. | Degrees Fahr. | Specific Gravity | Beaumé Gravity Standard | Per Cent Unsaturated |
|-------------------------|---------------|---------------|------------------|-------------------------|----------------------|
| 5                       | 79            | 209           |                  |                         |                      |
| 10                      | 87            | 227           |                  |                         |                      |
| 15                      | 93            | 241           | 0.7527           | 56.1                    | 36                   |
| 20                      | 99            | 254           |                  |                         |                      |
| 25                      | 103           | 264           |                  |                         |                      |
| 30                      | 107           | 275           |                  |                         |                      |
| 35                      | 112           | 286           |                  |                         |                      |
| 40                      | 116           | 295           | 0.7923           | 46.7                    | 33                   |
| 45                      | 121           | 306           |                  |                         |                      |
| 50                      | 125           | 315           |                  |                         |                      |
| 55                      | 130           | 325           |                  |                         |                      |
| 60                      | 138           | 338           |                  |                         |                      |
| 65                      | 140           | 349           | 0.8235           | 40.0                    | 30                   |
| 70                      | 145           | 359           |                  |                         |                      |
| 75                      | 152           | 376           |                  |                         |                      |
| 80                      | 158           | 388           |                  |                         |                      |
| 85                      | 165           | 405           | 0.8584           | 33.1                    | 40                   |
| 90                      | 175           | 427           |                  |                         |                      |
| 95                      | 193           | 467           |                  |                         |                      |
| End point               | 207           | 501           |                  |                         |                      |
| Per cent Loss           | 2.5           |               |                  |                         |                      |

## UNSATURATED HYDROCARBONS

In the cracking of hydrocarbon material in general the four types predominant are:

1. Paraffins.
2. Unsaturated compounds as acetylenes, olefins, and terpenes.
3. Naphthenes.
4. Aromatics.

Since it is generally held that the heat treatment of oil shale is a cracking phenomena, then the type of compounds formed under thermal treatment is a function of the temperature under which retorting takes place. Since this is so then the percentage of unsaturated hydrocarbons in the distillates must be dependent upon the percentage of carbon and hydrogen in the oil shale under treatment at the particular stage of shale decomposition. But, the problem is greatly complexed by the presence of sulphur, nitrogen and oxygen present in the starting material as is witnessed by the

decreasing yield of water every 100 c.c. distillate over, and the increase of the ammonia yield with increase of temperature.

In table No. VII, the surprising result is shown of the percentage of unsaturates indicating two maxima, and one minimum value. A maximum of 32 per cent is shown in the first ten per cent cut decreasing to twenty-four per cent and then reaching a maximum value in the last cut. In all thermal and pressure treatment of hydrocarbon material as petroleum oils the percentage yields of unsaturates increase from a minimum to a maximum and then a minimum value. There is a question as to whether the absorbed by 1.84 specific gravity acid method<sup>1</sup> registers only unsaturated hydrocarbons. From the amount of nitrogen and sulphur compound and water distilled over, we may well be dealing with some alkylamines, diamines, imines, amides, thioamides, anilides and nitriles, pyridine, pyrrol and quinoline bases.

TABLE VII. PER CENT OF UNSATURATES IN DISTILLATION CUTS FROM RECOVERED OIL

| Per Cent Unsaturates in Recovered Oil, 31.0 |  | Per Cent Unsaturate in Cuts |  |
|---------------------------------------------|--|-----------------------------|--|
| Distillation Cuts Per Cent                  |  |                             |  |
| 0-10                                        |  | 32                          |  |
| 10-20                                       |  | 26                          |  |
| 20-30                                       |  | 24                          |  |
| 30-40                                       |  | 26                          |  |
| 40-50                                       |  | 30                          |  |
| 50-60                                       |  | 36                          |  |
| 60-70                                       |  | 40                          |  |
| 70-80                                       |  | 50                          |  |
| 80-90                                       |  | 50                          |  |
|                                             |  | Whole mass solid            |  |

A. H. Allen<sup>2</sup> gave a series of values upon the reactive properties of olefins in shale and petroleum products. He assumed that the relative proportion of olefins present in two products of similar density and boiling points is fairly accurately indicated by the power of assimilating bromine. Hence, the following table No. VIII, would show the relative amounts of olefins present in shale and petroleum products:

TABLE VIII.

|                 | Shale Products           |                             | Petroleum Products       |                             |
|-----------------|--------------------------|-----------------------------|--------------------------|-----------------------------|
|                 | Specific Gravity 15.5°C. | Per Cent Bromine in Product | Specific Gravity 15.5°C. | Per Cent Bromine in Product |
| Gasoline        | 0.665                    | 41.6                        | 0.652                    | 4.8                         |
| Naphtha         | 0.718                    | 48.7                        | 0.690                    | 4.8                         |
| Burning oil     | 0.801                    | 27.9                        | 0.800                    | 14.7                        |
| Burning oil     | 0.806                    | 26.7                        |                          |                             |
| Lubricating oil | 0.875                    | 31.2                        | 0.862                    | 17.7                        |
| Lubricating oil | 0.889                    | 36.0                        | 0.905                    | 24.1                        |

Although Allen does not give details as to the method of production, conditions under which olefins formed, and sources of his shale and petroleum products, the data are interesting in qualitatively verifying the data in table No. VII. The shale oil products, as the specific gravity increases, shows a decrease in unsaturates and then an increase similar in nature to those found by the writers. However, it is certain that petroleum products are not complexed to the same extent by various nitrogen, oxygen and sulphur compounds as are the oil shale products.

#### AROMATIC HYDROCARBONS

The formation of aromatic hydrocarbons during the decomposition of the bituminous material present in the shale was suspected, hence a test was made for benzene, toluene, xylenes, naphthalene and anthracene. The oil was fractionated by means of a Hempel

Column several times, and the cut between 78° and 82° C. analyzed for benzene by using a 2:1 concentrated sulphuric-fuming nitric acid mixture, and heating so as to form dinitrobenzenes. The dinitrobenzenes were treated with alcohol and 1-3 dinitrobenzene crystallized out with a melting point of 89.7° C. Toluene was tested for in the distillation cut from 107°-113° C., by treating with a concentrated nitric sulphuric acid mixture according to the Langenscheidt method.<sup>3</sup> The TNT formed was recrystallized from alcohol and gave a melting point of 80.2° C. The xylene cut of 137-142° C. was nitrated in a similar manner, but care was taken so as not to form benzoic or phthalic acid from the oxidation of the side chains. The 2-4-6 trinitro-xylene was isolated by crystallization and identified by its melting point of 181.5° C.

The tests for naphthalene and anthracene were subject to great difficulties due to the large amount of solid paraffin present and their separation was not successful. However, it is unlikely that more than a trace of these two hydrocarbons could have been present due to the relatively low temperature of retorting the shale. The formation of naphthalene and anthracene are relatively high temperature reaction products.<sup>4</sup> But, it is certain that naphthalene and anthracene would form at higher temperatures in the destructive distillation of oil shale.

The percentage of aromatic hydrocarbon formation of benzene, toluene and xylene under the conditions of these experiments was small, but, the recovered oil could be retorted again in gas machines and give commercial yields of these products.

#### ANALYSIS OF WATER RESULTING FROM THE THERMAL DECOMPOSITION OF THE OIL SHALE

The water distillate was an amber-colored liquid with a strong odor of ammonia and heterocyclic nitrogen compounds like pyrrol, pyridine and similar substances. The percentage of this water distillate upon the total liquid recovered was 25.2 and upon a weight basis of a ton of shale, 3.0 per cent. The oil and water distillate as the retorting progressed, was collected in 100-c.c. samples. The following table No. IX, gives the per cent of water in the 100 c.c. fractions of oil and water distillates.

TABLE IX.

| 100 c.c. Samples   | Per Cent of Water |
|--------------------|-------------------|
| 1                  | 59.0              |
| 2                  | 37.0              |
| 3                  | 26.5              |
| 4                  | 13.0              |
| 5                  | 11.0              |
| 6                  | 17.0              |
| 7 (Basis 100 c.c.) | 9.2               |

Upon analysis a composite sample of the water distillate gave the following data in table No. X.

TABLE X.

|                                     |                     |
|-------------------------------------|---------------------|
| Specific gravity                    | 1.022               |
| H <sub>2</sub> S per cent           | 0.179               |
| CO <sub>2</sub> per cent            | Trace               |
| NH <sub>3</sub> per cent            | 1.580               |
| Ether extraction per cent           | nil (practically)   |
| CS <sub>2</sub> extraction per cent | 0.0225              |
| Reaction to litmus                  | alkaline (strongly) |

In the extraction by carbon bisulphide a wax-like solid was separated which had a pungent odor of heterocyclic nitrogen compounds, stronger than the original water solution. No further work was possible

<sup>1</sup>Elloff and Twomey, Met. and Chem. Eng. 14, 1916.

<sup>2</sup>Ibid.

<sup>3</sup>Analyst 6, 177, 1881.

<sup>4</sup>Z. Ges. Schless-Sprengstoff 7, 425.

<sup>5</sup>Elloff and Twomey, Jour. Phys. Chem. 20, 121, 1916.



on this waxy solid due to the small amount obtained. To investigate this point would require the retorting of at least one ton of oil shale.

### PHENOLS

The formation of phenolic compounds due to retorting oil shale is to be expected, when one considers the amount of oxygen in the starting material, and the percentage of water and oil distillate given off. But, the yield seems to be much smaller than one would be led to expect. Thomas Gray<sup>5</sup> in 1902 treated 3,200 gallons of "green naphtha" obtained from Scotch shale with 28 gallons of (27 per cent) sodium hydroxide solution. The aqueous solution was separated and the phenolic compounds precipitated out of solution with an excess of sulphuric acid which yielded approximately one and one-half gallons of crude phenols called "creosote oil" or 0.047 per cent of the "green naphtha" started with. During the distillation of a portion of this brown oily liquid the odor of sulphur dioxide, and hydrogen sulphide was noted.

Four hundred grams of "creosote oil" upon distillation gave the following results in table No. XI.

TABLE XI. CREOSOTE OIL

| Temperature  | Sixth | Distillation |
|--------------|-------|--------------|
|              | Grams | Per Cent     |
| Below 195°C. | 47.8  | 11.95        |
| 195 to 200   | 42.4  | 10.60        |
| 200 to 205   | 49.4  | 12.35        |
| 205 to 210   | 46.2  | 11.55        |
| 210 to 215   | 36.4  | 9.13         |
| 215 to 220   | 22.7  | 5.68         |
| 220 to 230   | 21.6  | 5.40         |
| 230 to 255   | 3.7   | 0.93         |

The first distillation residue above 230° C. was pitch-like in character and was 16 per cent of the creosote. After thirteen distillations phenol was found to be present in a small amount. The (o) and (m) cresols were separated but no (p). The 1, 2, 4 and 1, 3, 5 xylenols were identified and a very small quantity of guaiacol. In table No. XII is given the approximate percentages of the phenols, as calculated from the data of Gray.

TABLE XII.

Phenols from 3,200 gallons "Green Naphtha"  
1.5 Gallons Creosote Oil from 3,200 Gallons "Green Naphtha"

|                            | Per Cent in<br>1.5 Gallons<br>Creosote<br>Oil | Gallons | Per Cent on Basis<br>of 3,200 Gallons<br>"Green Naphtha"<br>Started With |
|----------------------------|-----------------------------------------------|---------|--------------------------------------------------------------------------|
| Phenol                     | 5-6                                           | 0.0825  | 0.0025                                                                   |
| (o) Cresol                 | 12-15                                         | 0.2025  | 0.0063                                                                   |
| (m) Cresol                 | 15-17.5                                       | 0.2438  | 0.0076                                                                   |
| Xylenols                   | 15-17.5                                       | 0.2438  | 0.0076                                                                   |
| Guaiacol                   | Very small                                    |         |                                                                          |
| Phenols—B. P. above 230°C. | 16.0                                          | 0.2400  | 0.0075                                                                   |

The percentage of phenolic compounds has been calculated on the basis of the 3,200 gallons of "green naphtha" started with, by taking the mean of the values recorded by Gray. These percentage yields indicate the slight phenolic compound formation due to the thermal decomposition of oil shale, when one considers that several hundred tons of oil shale are required to form 3,200 gallons of "green naphtha." Despite this large amount of oil shale retorted, Gray stated that to separate the phenolic compounds formed, even a larger quantity of "green naphtha" would be necessary; hence, probably, 1,000 or more tons of oil shale retorted would be necessary to determine the various phenols present. It has been stated that American oil shale will produce greater quantities of phenolic

compounds than the Scottish. This may be so, but as far as the writers are aware no experimental data has appeared.

In the present work a careful analysis was made of the recovered oil for phenolic compounds, but the sample obtained from the retorting of shale was much too small for anything more than a mere qualitative test. As the above work by Gray indicates, a very large amount of oil would have to be treated to isolate the phenolic compounds present.

A 50-c.c. sample of the cut between 170°-190° C. of the recovered shale oil was treated, with a 20 per cent sodium hydroxide solution, and then neutralized with sulphuric acid. The solution was filtered and distilled, a strong odor of phenol being noted at the end of the condenser. Part of the distillate was treated with bromine water, and a very small slightly yellowish precipitate of 2, 4, 6 tribromophenol was indicated. The distillate was also treated with ferric chloride which gave a violet coloration in the solution which is a characteristic test for phenol, but it must be remembered that other phenolic compounds give violet colored solutions upon treatment with ferric chloride. The phenol present was no more than a trace. A further search was made to isolate other phenolic compounds of the di-tri and tetra hydroxy benzene and hydroxytoluene, xylene and mesitylene, but without success with the amount of oil at hand. A piece of research of the highest importance in connection with American oil shale retorting is to determine the commercial yields of not alone the phenolic compounds of the above type but also as to whether thymol and carvacrol are formed and furthermore, phenol—alcohol—ethers must also be produced of the type of anisole, phenetole and phenol ether, as diphenyl oxide.

### THIO-DERIVATIVES OF PHENOL

Due to the fact, that the water distillate resulting from the thermal treatment of the oil shale under discussion gave 0.179 per cent of hydrogen sulphide, the writers endeavored to isolate and identify thiofen, mercaptans of the paraffin and aromatic types. That thiophenol, phenyl sulphide, thioanisole, thiophenetole and similar compounds are formed is reasonably certain, for their formation is along similar lines to the oxygen alcohols, ethers of the paraffin and aromatic series. In this communication the only sulphur compound isolated and identified with certainty was hydrogen sulphide, and further work along this line awaits the retorting of a very large quantity of shale, as also for the further identification of phenolic compounds in shale oil.

### HETEROCYCLIC NITROGEN COMPOUNDS

The researches of Anderson,<sup>7</sup> Hofman<sup>8</sup> and Stenhouse<sup>9</sup> have indicated that when nitrogenous material of organic derivation is subjected to destructive distillation some of the products formed are ammonia and volatile organic bases. It would then be expected that bituminous material like oil shale containing nitrogen would likewise produce heterocyclic nitrogen compounds of the pyrrol, pyridine, quinolind and acridine series, similar

<sup>7</sup>Edinburgh Phil. Trans. XX 2, 247. Jour. Chem. Soc. 4, 112, 1852.

<sup>8</sup>Jour. Chem. Soc. 4, 304, 1852. Ibid 3, 279, 1851.

<sup>9</sup>Jour. Chem. Soc. 3, 399, 1851.

<sup>5</sup>Soc. Chem. Ind. Jour. 21, 845, 1902.

to the destructive distillation of wood, bone, coal and the varied nitrogen containing organic material.

Williams, working upon a crude naphtha resulting from the retorting of a Dorsetshire shale rich in fossilized animal remains isolated a number of heterocyclic nitrogen compounds of the pyrrol and pyridine series. He treated crude naphtha with sulphuric acid to extract the bases. The tarry matter was separated by boiling with water, during which pyrrol was evolved, and tested for by means of fir wood moistened with hydrogen iodide which turned to an intense purplish red. The sulphuric acid was then neutralized with potassium hydroxide and subjected to distillation. A nonbasic oil was separated by saturating the distillation product with hydrogen iodide, and the liquid again neutralized, and distilled. The ammonia was collected by passing through a strong solution of potassium hydroxide in which the bases were insoluble. The water present was taken up and removed by sticks of sodium hydroxide. The liquid was refractionated many, many times and fractions collected every 10° F.

The bases obtained were limpid, colorless and highly refractive. A persistent odor was noted which was pungent. The fractions burned with a smoky flame and fumed strongly in the presence of hydrogen iodide. The bases dissolved in hydrogen iodide with an evolution of heat and formed deliquescent salts. They dissolved readily in alcohol or ether. Upon the addition of cupric nitrate a complex precipitate like  $(\text{CuNH}_3)_2$  was formed which dissolved in excess. The bases with boiling points below 320° F. dissolve readily in water, but above this temperature to a lesser extent. Those with boiling points below 320—10° F. gave a beautiful green coloration upon treatment with bleaching powder.

The volatile bases were analyzed by means of precipitation with  $\text{PtI}_4$  (author states  $\text{PtI}_2$ ) and crystallization of platinum salts of these bases which is a much more reliable method than distillation. The following heterocyclic nitrogen compounds were isolated and identified from a crude naphtha resulting from the retorting of oil shale.

|                              |                                                 |
|------------------------------|-------------------------------------------------|
| Pyrrol                       | $\text{C}_4\text{H}_7\text{N}$                  |
| Pyridine                     | $\text{C}_5\text{H}_7\text{N}$ (Formula?)       |
| Picoline (methyl pyridine)   | $\text{C}_6\text{H}_7\text{N}$ (Formula?)       |
| Lutidine (dimethyl pyridine) | $\text{C}_7\text{H}_9\text{N}$ (Formula?)       |
| New base (?)                 | $\text{C}_8\text{H}_{11}\text{N}$ (Formula?)    |
| Parvaline                    | $\text{C}_{10}\text{H}_{13}\text{N}$ (Formula?) |

Beilby<sup>11</sup> believes that animal vegetable matter tends toward the formation of carbonaceous material with the original nitrogen being retained. He states that all oils reacting from the destructive distillation of carbonaceous material containing nitrogen, more or less altered older organic remains, behave much the same as the original substance would have done. Albumen and gelatin and corresponding vegetable matter yield on thermal distillation:

1. Ammonia.
2. Oil rich in alkaloidal bodies.
3. Carbonaceous residue containing large proportions of original nitrogen.

When more or less altered deposits of peat, coal, shale, etc., are distilled a similar redistribution of the

nitrogen takes place. A distribution of the nitrogen in shale is shown after distillation in table No. 13.

TABLE XIII

|                              | Per Cent Nitrogen |
|------------------------------|-------------------|
| Ammonia in water distillate. | 17 0              |
| Oil as alkaloidal tars       | 20 4              |
| Coke residue                 | 62 6              |

He argues that the nitrogen of the shale started with upon retorting redistributes itself with a higher percentage in the higher boiling point fractions and reaches a maximum in the residue. The alkaloidal tars studied by him were approximately one-fourth by weight of the oil distillate. In the particular distillate studied the oil portion contained 1.16 per cent nitrogen while the alkaloidal tar contained 4 per cent. Upon redistillation of the tar and making ten fractions, the distribution of the nitrogen was, as is shown in table No. 14, although some of volatile alkaloids were lost.

TABLE XIV.

| Fraction | Per Cent Nitrogen |
|----------|-------------------|
| 1        | Lost              |
| 2        | 3 54              |
| 3        | 3 37              |
| 4        | 3 35              |
| 5        | 3 34              |
| 6        | 3 47              |
| 7        | 3 54              |
| 8        | 3 35              |
| 9        | 3 54              |
| Residue  | 4 00              |

The latter fractions were subjected to a red heat which indicates the relative stability of the nitrogen compounds. The formation of ammonia from reforming shale is a function of the conditions of temperature, time, retort and other factors, and that when heating is conducted slowly a decomposition of the alkaloids takes place producing more ammonia. The shale referred to above was then distilled very slowly and gave the following results in table No. 15.

TABLE XV.

|                                               | Per Cent Nitrogen |
|-----------------------------------------------|-------------------|
| Total nitrogen                                | 0 70              |
| As ammonia in water distillate                | 0 23              |
| As alkaloids in oil                           | 0 14              |
| In coke                                       | 0 32              |
| Loss                                          | 0 01              |
| Calculating on Basis of Total Nitrogen as 100 |                   |
| As ammonia in water distillate                | 32 8              |
| Alkaloids in oil                              | 20 0              |
| In coke                                       | 45 7              |
| Loss                                          | 1 5               |

The latter experiment shows clearly the time factor in the increasing of the yield of ammonia at the expense of the alkaloids present in the residue coke.

Beilby made a series of nitrogen determinations of various oils, ozokerite, residuums and coke from Scotch shale, American residuum and coke and Galician ozokerite, the results of which are shown in table No. 16.

TABLE XVI.

|                               | Per Cent of Nitrogen |
|-------------------------------|----------------------|
| Scotch shale oil from retorts | 1 160                |
| Scotch petroleum or ozokerite | 2 296                |
| American petroleum residuum   | 0 080                |
| Galician ozokerite            | 0 188                |
| Scotch basic tar              | 3 900                |
| American residuum tar         | 0 710                |
| Scotch crude still coke       | 3 200                |
| American crude still coke     | 0 375                |

The work of Beilby indicates that the nitrogen present in the original bituminous material increases in the latter fractions during retorting, reaching a maximum in the residue; furthermore, that during distillation of the shale only the more volatile alkaloids come off and the residue still contains the less volatile or pitchy nitrogenous bodies, and that it is probable that there are series of unbroken continuity from the volatile

<sup>11</sup>Chem. Soc. Jour. 7, 97, 1854. Philo. Mag. 11th ser. vol. 8, 203, 1854.

<sup>12</sup>Soc. Chem. Ind. Jour. 3, 216, 1884

pyridine, picoline up to pitchy or coke-like substances. Diagrammatically this is shown as follows:

| Oil Shale                                                |                                  |                                                           |
|----------------------------------------------------------|----------------------------------|-----------------------------------------------------------|
| Hydrocarbons                                             | Alkaloids (?)                    | Higher alkaloids or substances like Carbazole $C_8H_7-NH$ |
| $C_2H_4$ to $C_{20}H_{40}$<br>$C_3H_8$ to $C_{20}H_{42}$ | $C_8H_9N$ to $C_{12}H_{17}N$ (?) |                                                           |

In the present work the heterocyclic nitrogen compounds were not isolated due to the amount of distillate oil and water recovered not being sufficient for a close analysis. Attempts were made to isolate the volatile bases by means of precipitation and crystallization of the hydrochlorides, sulphates and platinichlorides, but too many complexes were formed which we were unable to separate—due to not being able to fractionate the starting material into close boiling fractions. However, that pyridine and its homologs are present is certain, for their characteristically pungent odor was noted clearly. The further study of these heterocyclic nitrogen compounds will be carried on, when sufficient starting material is obtainable. Due to the close analogy of the thermal decomposition products of bituminous material containing nitrogen, oxygen and sulphur, as coal, bone, wood and shale, similar volatile base type products have been isolated. It is suggested that when shale oil is thoroughly investigated, compounds of the furfurane, thiophene, pentamethylæne oxide and penthophene series will be isolated. They are so closely interwoven, synthesized and analogous in their behavior to some extent to the benzenes, phenols and one another as the formation of dimethyl furfurane, thiophene and pyrrol from acetyl acetone, shows that similar synthesizing must occur when oil shale is subjected to thermal treatment.

#### PRODUCTS RECOVERED ON BASIS TON OIL SHALE RETORTED

In table No. 17, the results from retorting twelve pounds of oil shale are tabulated, with percentage yields of various products. Furthermore, the products based upon a ton of oil shale compare fairly closely with the results obtained by retorting one pound of the same shale. This particular oil shale from Colorado would average between twenty and twenty-one gallons of oil per ton and approximately twenty-five pounds of ammonium sulphate.

TABLE XVII. PER CENT PRODUCTS FROM OIL SHALE

| Oil Shale                           | Pounds | Kilograms     | Per Cent |
|-------------------------------------|--------|---------------|----------|
| Charge used                         | 12.00  | 5.87          |          |
| Spent shale                         | 10.00  | 4.89          | 83.3     |
| Oil recovered                       | 0.91   | 0.45          | 7.6      |
| Water recovered                     | 0.35   | 0.17          | 3.0      |
| Ammonia                             | 0.04   | 0.21          | 0.3      |
| Gas and loss                        | 0.61   | 0.34          | 5.8      |
| Products per Ton Oil Shale Retorted |        |               |          |
| Oil                                 |        | 20.7 gal.     |          |
| Total permanent gas                 |        | 1,920 cu. ft. |          |
| Sulphate of ammonia                 |        | 23.3 lb.      |          |

The following list of compounds have been isolated by various workers in oil shale retorting. They are fairly well diversified, but with further research in all likelihood there will be approximately as many different compounds identified as there have been from coal tar. Shale oil is an exceedingly complex mixture of hydrocarbon, oxygen, sulphur and nitrogen compounds

of complex structure, which would require the highest technical skill to separate for industrial use.

#### COMPOUNDS ISOLATED FROM OIL SHALE RETORTING

|                  |     |            |     |
|------------------|-----|------------|-----|
| Carbon monoxide  | (a) | Chrysene   | (c) |
| Carbon dioxide   | (a) | Pyrene     | (c) |
| Hydrogen         | (a) | Phenol     | (d) |
| Methane          | (a) | (m) cresol | (d) |
| Ethylene         | (a) | Xylenols   | (d) |
| Oxygen           | (a) | Guaiacol   | (d) |
| Nitrogen         | (a) | Pyrrol     | (c) |
| Ammonia          | (a) | Pyridine   | (c) |
| Hydrogen sulfide | (a) | Picoline   | (c) |
| Benzene          | (b) | Lutidine   | (c) |
| Toluene          | (b) | Parvoline  | (c) |
| Xylene           | (b) | Quinolins  | (c) |

(a) Roman J. Soc. Chem. Ind. 10, 436, 1891.  
(b) Present research.  
(c) Bacon and Hamor American Petroleum Industry.  
(d) Gray, Chem. Soc. Jour. 21, 845, 1902.  
(e) Williams, Soc. Jour. 7, 97, 1854.

#### GENERAL SUMMARY

1. The derivation of oil shale is in all probability of the same origin as petroleum oil. The formation of bituminous shales is mainly due to slow evaporation of the impregnated oil, vegetable and animal matter in clays before or after being consolidated into shale.

2. The per cent of unsaturates in the distillation cuts of the shale oil showed the unusual phenomenon of two maxima and one minimum. In the first 10 per cent cut the percentage of unsaturates was 32, decreasing to 24 in the 20 to 30 per cent cut, increasing then to 50 per cent unsaturates in the 80 to 90 per cent cut.

3. Benzol, toluol and xylol were present in small amounts in the shale oil recovered.

4. The following phenols have been isolated from shale oil: phenol, (c) (m) cresol, xylenols and guaiacol.

5. Pyrrol, pyridine, picoline, lutidine and parvoline have been found in shale oil.

6. Scotland in 1916 produced 600,000 gallons or 14,260 barrels of gasoline or 0.7 per cent on the total oil recovered from the retorting of 3,500,000 tons of shale. The amount of gasoline produced in the United States in 1916 was 2,500,000,000 gallons. Scotland's production calculates 0.00024 per cent of this amount. The United States exported 110,000,000 gallons of gasoline to the United Kingdom of England in 1917.

7. The oil-shale industry of France is declining, and from government reports France is practically dependent for her oil supplies upon foreign countries.

8. In New South Wales the industry has declined for a number of years, and is at the present time more or less at a standstill. The tons of oil shale retorted dropped from 59,426 in 1895 to 17,425 in 1916.

9. The following tabulation covers the gallons of oil yield per ton of shale retorted in various countries and localities of the United States:

| Shale From                  | Gallons Oil Per Ton | Pounds Ammonium Sulphate Per Ton | Average              |
|-----------------------------|---------------------|----------------------------------|----------------------|
| Utah                        | 25.0                | 13.3                             | 38 samples           |
| Wyoming                     | 16.4                | 15.0                             | 42 samples           |
| Colorado                    | 16.2                | 19.1                             | 51 samples           |
| Present Research (Colorado) | 20.5                | 24.4                             | 2 samples            |
| Scotland                    | 23.0                | 38.0                             | 3,500,000 tons shale |
| Canada                      | 34.9                | 51.3                             | 44 samples           |
| France                      | 20.7                |                                  | 184,030 tons         |
| New South Wales             | (a)                 | (a)                              | 17,425 tons          |
| Black Shale:                |                     |                                  |                      |
| Pennsylvania                | 27.6                | (a)                              | 7 samples            |
| Illinois                    | 14.0                | (a)                              | 2 samples            |
| Indiana                     | 10.0                | (a)                              | 7 samples            |
| Ohio                        | 7.1                 | (a)                              | 4 samples            |
| Tennessee                   | 5.2                 | (a)                              | 13 samples           |
| Kentucky                    | 5.1                 | (a)                              | 3 samples            |
| W. Virginia                 | 1.4                 | (a)                              | 5 samples            |
| Cannel Coal:                |                     |                                  |                      |
| Missouri                    | 51.4                | (a)                              | 6 samples            |
| Illinois                    | (a)                 | (a)                              | 2 samples            |
| Pennsylvania                | 29.6                | 17.2                             | 5 samples            |

(a) Not determined.



In prospectuses, and a number of articles appearing in the oil journals of the country for calculating possible profits from oil shale retorting, the gallons of oil per ton of shale taken, range usually between 42 and 60. But, the above data indicate clearly that an average of shale retorting one-half these values would approximate the gallonage yield of oil per ton of shale retorted. The three states Utah, Wyoming and Colorado have been most carefully studied and the average of 133 samples collected approximate 20 gallons of oil per ton shale retorted.

10. It has been stated that there is sufficient shale in Colorado to produce twenty billion barrels of oil from which two billion barrels of gasoline may be extracted by the ordinary methods of refining. It is certain that no such amount of gasoline is obtainable from twenty billion barrels of oil resulting from retorting Colorado shale. Although nine samples distilled gave approximately 10 per cent of distillate with a volatility similar to gasoline, it is, however, not a gasoline suitable for internal-combustion engines. It is a distillate composed of paraffin hydrocarbons, unsaturated hydrocarbons, nitrogen compounds, sulphur and oxygen compounds. In fact, the complexity of the distillate due to the presence of alkaloidal bases, sulphur compounds and phenols, make it impractical to refine by the ordinary sulphuric acid-caustic soda method prevalent in ordinary refinery practice. Scotland has averaged less than one per cent of marketable gasoline from her shale retorting experience of over fifty years. Can we reasonably expect ten times as much gasoline from the retorting of Colorado shales, than Scotland does from her shales? The experimental evidence shows that the 10 per cent distillate of gasoline volatility from shale oil, will suffer a heavy loss upon refining to produce a marketable gasoline suitable for internal-combustion engines; furthermore, that nothing like 10 per cent or 2,000,000,000 barrels of gasoline will result from the refining of 20,000,000,000 barrels of shale oil from Colorado shale.

11. It is estimated that Southeastern Indiana is underlain with shale-bearing oil which contains 100,000,000,000 barrels of oil.

12. That oil shale is of the highest importance as a potential source of oil is certain. This has been recognized by our government in setting aside shale lands for the use of the navy. The ultimate commercial importance of a shale oil industry in the United States is taken for granted. That it will be an industry requiring very large capital in these days of large capitalization is also positive. At the present time no large shale retorting plants are in existence in the United States, and the cost of installing one is problematical. Furthermore, much experimentation will have to be carried on and the highest technical skill will be required to develop a shale-oil industry in the United States. That shale oil, even with ammonium sulphate as a byproduct can compete at the present time or in the near future with petroleum crude is questionable. For, it must be recognized that new oil fields are being discovered constantly and though many of the known fields of the United States are declining new ones are coming to the fore. Also, Mexico has a potential oil production of known fields of at least 300,000,-

000 barrels a year, and the oil fields of South America have not been tapped as yet. Yet the great oil shale deposits safeguard the economic life of the United States and makes it certain that we will be self-sustaining as to petroleum products during any period of our national life for at least a century.

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**More Chromite Needed.**—The Geological Survey has issued a statement in regard to the chromite situation showing that the present domestic output of chromite is scarcely one-fourth of the quantity needed for war and domestic uses, so that the other three-fourths must be imported. Hitherto most of our imported chromite has come from Rhodesia and New Caledonia, and, notwithstanding the scarcity of ships, much of it still comes from those distant lands. In response to our call for chromite Canada has rendered us most efficient help. In 1916 she sent us 10,930 long tons and in 1917 she more than doubled her shipments of chromite to the United States. The domestic production of chromite in 1916 was about 14,000 long tons, and last spring the prediction was made by Government geologists that in 1917 it would reach 48,000 long tons. According to J. S. Dillon, of the United States Geological Survey, the latest returns indicate that this prophecy has been fulfilled. Most of the known bodies of chromite are small, and those that lie far from lines of transportation are not available for exploitation by the ordinary miner because of the difficulty and expense of getting the ore to the market. Much of the chromite on the Pacific Coast is of low grade, averaging about 40 per cent of chromic oxide, and on that account is of less value than the imported ore, which generally contains 50 per cent or more of chromic oxide. Nicaragua is shipping a small quantity of ore to this country. At Antioquia, Colombia, chromite is reported to be so abundant that it has been used to build the walls of houses. Brazil has valuable deposits several hundred miles northwest of Bahia and may yet become a contributor to our needed supply. Most of the chromite we use is needed in factories in the eastern United States, and on account of the difficulty and expense of long transportation from the western deposits one of our most urgent present needs is to increase the production of chromite in the Atlantic States. The chrome industry of America really began in the eastern States. The mines of Maryland and Pennsylvania once supplied the world's chromite. A recent examination by the Geological Survey of the old chrome mines in Lancaster and Chester counties, Pa., suggests the possibility of successfully concentrating some of the bodies of spotted chrome ore in that region.

Alcohol is being synthesized in commercial quantities from acetylene at Visp, Wallis, Switzerland, according to reports, which are emphasized by the recent article, "Gnomes in Chemistry," *Vossische Zeitung*, by Prof. Dr. K. Arndt. Acetylene, formed by the reaction between calcium carbide and water, is hydrolized in the presence of certain mercury salts yielding acetaldehyde, which is readily reduced by hydrogen in presence of a catalyst (nickel) to alcohol.

Synopsis of Recent Metallurgical and Chemical Literature

Our Fuel Situation, by MR. WILLIAM M. BOOTH, was among the papers read at the meeting of the American Institute of Chemical Engineers at Gorham. Mr. Booth gave a brief account of the transition of the wood fuel days into the present coal age. His table of the British Thermal Units one dollar will buy was very instructive:

|                   | B.t.u. @ \$1 00         |           |
|-------------------|-------------------------|-----------|
| Bituminous coal   | 13,500 b.t.u. per lb.   | 6,750,000 |
|                   | 2,000 lb. @ \$4 00      |           |
| Anthracite.....   | 13,500 b.t.u. per lb.   | 3,375,000 |
|                   | 2,000 lb. @ \$8 00      |           |
| Seasoned hardwood | 4,000 b.t.u. per lb.    | 2,700,000 |
|                   | \$8 00 per 4-ft. cord   |           |
| Natural gas ..... | 1,000 b.t.u. per cu.ft. | 3,333,000 |
|                   | 30c. per 1,000 ft.      |           |
| City gas.....     | 600 b.t.u. per cu.ft.   | 600,000   |
|                   | \$1 00 per 1,000 ft.    |           |
| Crude oil .....   | 19,000 b.t.u. per lb.   | 1,615,000 |
|                   | \$4 00 per bbl.         |           |
| Electricity.....  | 8c. per kw.-hr.         | 4,266     |
|                   | 1c. per kw.-hr.         | 34,128    |
| Alcohol.....      | 95% vol.                | 78,502    |
|                   | \$1 per gal. (6.58 lb.) |           |

WOOD FOR RURAL DISTRICTS—CENTRAL PLANTS FOR CITIES

Mr. Booth gave two tons as an average wood growth rate, per acre of land and thought that in the distant future, the farmer would grow his own fuel off of four or five acres of land. This would not be practical for the cities, for each family would need, on an average, 2000 cu.ft.—this transportation and storage space not being available. Much larger central gas plants will form the solution of the fuel problem in the cities, the overhead expenses of which will be proportionately less as they increase in capacity. Central heating plants can deliver steam for house heating purposes at a saving to the consumer not only of labor but of actual fuel costs in proportion as the plants grow larger, and better conducting pipe lines are provided.

COAL ECONOMY

Because of the comparative cheapness of coal in the past, manufacturers have heretofore never appreciated the future fuel tendencies—higher prices and poorer quality. With transportation and mining capacities unable to supply the present demands interest in the fuel economist is gradually growing. It is to be expected that in the future engineers will have large financial support in their work of attempting to improve the heat yields by the use of better designed equipment, and that preparations will now be forthcoming for the less-coal age. Peat, lignite and shale oil will eventually provide a fair source of material.

At the conclusion of the reading, discussion arose in regard to taking all the available water from Niagara Falls for certain periods of time for electric power generation. Those opposed to such drastic action thought that with the present prices of coal produced power, in all probability no financial gain commensurate with the æsthetic loss could be obtained. Upon a motion made by Mr. J. M. Weiss, it was finally decided to first obtain figure to show the exact relative fuel value of the falls to our coal consumption.

Manganese Steel Rails.—An account which the American Railway Engineering Association has published in Bulletin No. 199 by M. H. WICKHORST, gives the detailed circumstances of various track tests on manganese steel rails, and containing the following conclusions: Manganese steel rails abrade much slower than Bessemer or open-hearth rails on sharp curves, according to the following approximations for curves of 8 or 9 degrees: manganese 0.004 sq.in. per million tons of traffic; open-hearth, 0.012 sq.in.; Bessemer, 0.020 sq.in. The results vary considerably and are probably dependent on the nature of the rolling stock as well as the tonnage. Manganese steel rails become distorted by spreading and drooping of the head more easily than do the others, possibly due to the low elastic limit. Failures of early installations were extremely high, consisting mostly of transverse cracks in the head, but manufacturers claim to have perfected methods for producing a better quality in this respect. Very large deposits of pyrolusite are being developed in Brazil which will supply the demand should it become large.

Alcohol from Sulphite Waste Liquors.—Among the papers read at the June meeting of the American Institute of Chemical Engineers at Gorham, N. H., DR. RALPH H. MCKEE read a paper regarding the fermentation of the sugars in sulphite pulp waste liquor to alcohol without neutralizing the complex magnesia-lime organic acid-sulphite compounds.—Dr. McKee having found that yeast lived and functioned normally in this liquor while a current of air was being blown through. While his work has been limited to the scope of the laboratory, he recommended that the hot liquor from the blow off of the digestors be sprayed in a tower countercurrent to an air current with cooling arrangements so that it would arrive at the fermenting vats at less than 90° F., below which temperature yeast thrives.

ADVANTAGES OF PROCESS

Upon fractional distillation, some sulphur dioxide is present in the alcohol obtained but is readily removed by soda ash. The advantages of this process are claimed to be:

- 1. Saving of equipment.
- 2. No neutralizing with lime.
- 3. Saving in manufacturing costs.

During the subsequent discussion of the paper, MR. H. O. Chute confirmed the fact that yeast was materially aided by air blowing and added that some form of nitrogen and phosphorus had to be added. Mr. Hugh K. Moore asked if NH<sub>4</sub>Cl with the CaSO<sub>4</sub> present would be beneficial. Dr. McKee affirmed this and added that old yeast, hydrolysed at 120° F., made good yeast food. In discussing the form of still adapted to fractionating such a dilute solution of alcohol, Mr. Chute said that a still with a very high tower fractionating column was essential. No data were given regarding the effect of the air in removing or oxidizing the sulphite acids during the passage through the cooling tower, and subsequent fermentation, nor concerning the tendency of the gas sweeping action of the air blowing to carry off the alcohol vapor as it is produced in the vats by the yeast fermentation.





**Manufacture of Phosphoric and Hydrofluosilicic Acids.**—INGENUIN HECHENBLEICKNER, of Charlotte North Carolina, has already patented (1,167,775) improved apparatus for the electric furnace production of  $P_2O_5$ , which delivers the dusty furnace gases to a rotary kiln wherein the phosphate rock and silica are preheated, and thence into a dust catcher where the bulk of the true dust is removed before the temperature has dropped low enough to precipitate the phosphorous pentoxide vapor. This, together with its

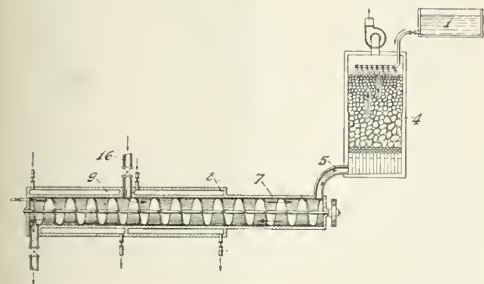


Fig. 3

usual content of silicon tetrafluoride, produced by the decomposition of the fluorite ordinarily present as an impurity in the charge, may be absorbed in water, forming a mixture of phosphoric acid ( $H_3PO_4$ ) and hydrofluosilicic acid ( $H_2SiF_6$ ) and which product when utilized in the manufacture of fertilizer may be employed without separation into its components. In case it is desirable to separate these acids, it may be done by cooling the dust-free gas to a point where the  $P_2O_5$  condenses, and then removing this condensate in a Cottrell treater. The  $SiF_4$  is carried on, to be absorbed in the ordinary counter current tower. (1,264,510.) The inventor also patents a variation of the furnace accessories, whereby a waste heat boiler is set close to the furnace, and which catches the true dust, cools the gases to about the condensation temperature of  $P_2O_5$ , and produces steam power. In this case the furnace charge is introduced around the electrodes. (Assigned to the Southern Electro-Chemical Co., 1,264,510; Apr. 30, 1918.)

**Deoxidizer of Titanium and Silicon.**—NAPOLEON G. PETINOT, of New York City, (assigned to United States Alloys Corporation) notes that in the ordinary practice of deoxidation of steel baths with titanium, the oxides produced, being very infusible, remain entrapped in the solidifying metal. He has found that a mixture of silicon and titanium oxides containing 15 per cent of the former has a low melting point, and, therefore, if a deoxidizer containing five times as much titanium as silicon be added to oxidized steel baths, the resulting reaction will produce a fusible slag readily eliminated from the solidifying metal. (1,252,023; Jan. 1, 1918.) For manufacturing this alloy, he uses a proper mixture of pure ingredients such as rutile, quartz, charcoal and steel turnings. This is smelted in an electric furnace with a carbon bottom, and the end of the reduction of the thin layer of iron silicate slag temporarily formed is noted by the extreme instability of furnace operation, accom-

panied by the copious projection of molten metal from the bath. (1,260,037; Mar. 19, 1918.)

**Concentration of Sludge Acid.**—In the refining of petroleum, the oils are always treated with sulphuric acid, the acid and the withdrawn matters then settle out as a heavy sludge. This sludge is ordinarily treated with water, causing a separation into an oily layer called sludge oil, and an aqueous sulphuric acid containing many carbonaceous matters. WM. A. SLATER, of Fort Worth, Texas, finds that the concentration of this waste sludge acid for reuse may be effected by hot air. Instead of forming great volumes of sulphur dioxide by the reaction between the dissolved organic matters and the acid, as is usual when such acid is heated, there is separated granular carbon harmless in subsequent use, and very little oxide is liberated. The inventor attributes these results to "autoxidation" of the organic matters in the hot concentrating acid by the hot air; the sulphur dioxide which tends to form and the organic matter probably oxidizing simultaneously in the manner usual in autoxidations. Fig. 4 shows an arrangement suitable for performing the concentration—the pump 4 forces air through heating coils 1 placed in the flues of nearby stills, and delivers air at about 400 deg. F. to the concentrating tank 8, constructed tightly of acid proof material and having the necessary drains, manholes, thermometers and other auxiliaries. This hot air bubbles through the weak acid to be concentrated, and escapes from the tank, containing some atomized acid, by pipe 16, entering the bottom of the tower 17. Here it ascends against dripping weak acid circulated from tank 22. The air is further scrubbed in the water column 20, and finally escapes. The scrubbing water stored in tank 29 is used to dilute the sludge acid, which latter is the material circulated in tower 17, later to enter concentrator 8. Carbon separates from the acid in circulation through the aeration tower; separating in a rather peculiar form as brittle, round balls. This carbon settles at the bottom of tank 22 and is removed from time to time by cleaning. In

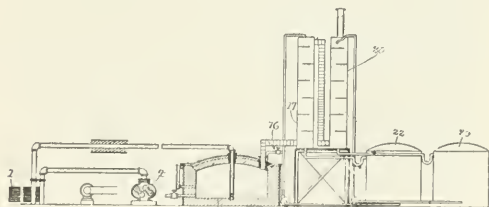


Fig. 4

normal operation the acid in tank 22 is at a temperature of about 200° F. The carbon forming in the concentrator is finely granular and is kept in suspension by the stirring action of the air, and is withdrawn with the concentrated acid. It is found that the temperature required to finish the acid up to 66 deg. Bé. varies somewhat, so that after the temperature reaches say 320 deg. F. it is tested from time to time and withdrawn when the necessary concentration is reached. (Assigned to Gulf Refining Co., 1,262,950; Apr. 23, 1918.)

## A Modern Laboratory for Industrial Research

THE research and testing laboratory of Arthur D. Little, Inc. at Cambridge, Mass., is the fulfillment of plans laid long ago to make effective research easily available to American industry. It is but two and a half minutes' ride by subway from Park Street station in the heart of Boston, to Kendall Square, Cambridge; and from Kendall Square to the laboratory on the Charles River Road is but a four-minute walk. It is an ideal place for work, being at once quiet, sunny and pleasant. The building fronts on the Charles River Basin and beyond it on the further shore is the Back Bay District of Boston, while to the southwest there looms Beacon Hill, the golden dome of the Bulfinch State



LABORATORY IN MARCH, 1918

House and, if tradition is to be trusted, the Sacred Codfish. Along the river road to the west of the laboratory are the monumental buildings of the Massachusetts Institute of Technology.

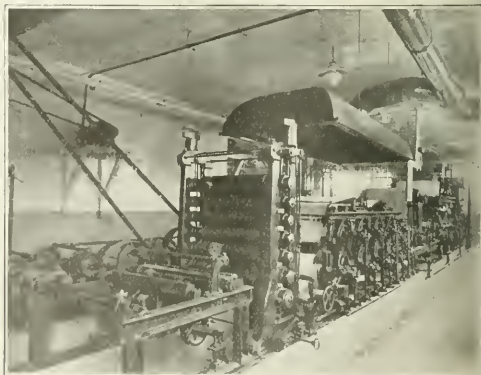
The first floor of the laboratory is devoted generally to the administrative and accounting department. It contains the offices of the president; the vice presidents, treasurer, secretary and service manager, the head of the commercial department, offices of several engineers, the drafting and accounting rooms and the museum. The museum is an interesting place. Its purpose is to show the relations of raw material to finished products over a wide range of industries. Types of cellulose and the long series of bodies made from it, a great variety of wood products, also a large number of minerals and their metallurgical products are displayed. We have not the space to describe it in detail, but shall content ourselves with saying that it is an enlightening experience for a business man to visit it. Even those with technical training find many surprises. Many maps are in preparation showing the known locations of materials all over the Western Hemisphere.

The second floor is devoted to research. Several of the laboratories are in full operation, while others are not yet completely equipped. Various details of the special equipments change from time to time, according to the nature of the problem in hand.

An interesting feature in regard to problems, as they come in, is that they seem to be addicted to fashions and styles. At present the preponderance of needs seems to be along the lines of applied colloidal chemistry.

On the second floor is a technical library which contains over 30,000 sources of information, indexed by means of over 100,000 cards. This part of the establishment holds the records of over 30 years in industrial research and a great mass of technical reports, bound in manuscript and indexed. It contains also in addition to the many books and sets of scientific periodicals, a large accumulation of clippings from all kinds of sources, filed in envelopes and indexed. The library occupies three rooms and bears a very favorable reputation among librarians because of its arrangement. It has been visited by the school for librarians at Albany, which is spoken of with favor by the guild; and in consulting practise it is found to be in constant use by members of the staff. A very well equipped textile laboratory is also on the second floor.

Analyses and tests are made on the third floor, excepting certain operations, which are carried out in the basement. The general analytical laboratory is at the eastern end of the building and is symmetrically arranged with double parallel rows of hoods made of alberene stone extending east and west on either side of the center. The northern end is devoted to metallurgical analyses, beginning with those of iron and steel. There is an electric furnace with five independent tubes for carbon determinations and a capacity of ten tests per hour. Determinations of copper, zinc, lead, nickel and cobalt are made by electrolysis. The rest of the laboratory is, properly speaking, of a general analytical nature and we shall only attempt to note some of the features observed in passing through. Extractions with water and high-boiling organic solvents are made here. Six oxygen tanks are in constant circulation. There are Freas drying ovens, a Freas incubator, a Hoskins electric furnace and much other highly special as well as general apparatus. Every hood has a gas hot-plate and a steam-bath with ten openings. At the end of each of the four rows of hoods is a section, which may be sealed for poisonous vapors. A water-still supplies the entire laboratory with distilled water through block tin pipes and silver faucets. Balance and volumetric rooms,



THE PAPER MILL

the latter equipped with daylight-lamps, connect with the general analytical laboratory. A separate laboratory with a calorimeter room containing an Emerson gold-lined calorimeter is provided for fuel testing. A

special room is equipped for extractions with inflammable solvents and for the recovery of the same. The optical room contains microscopes of various power and grade, a penetrometer for tars and asphalts, micrometers for determining the thickness of paper and other sheet materials, an ultra violet light apparatus of the same power and design as that used in the U. S. Bureau for Testing Materials, and about a hundred samples of paper of known composition with which com-



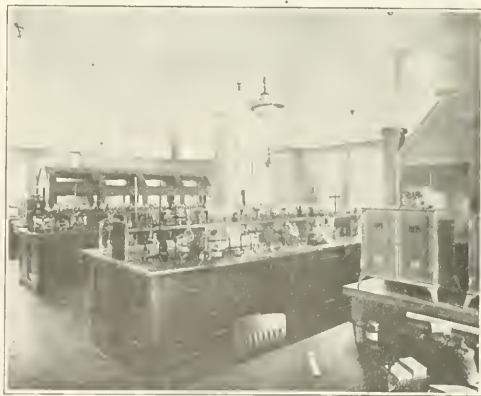
COMPLETE RECTIFYING STILL

for the convenience of the janitor) has been turned into a special research laboratory. Still another room is used for storing office files. The boiler room is in the rear. At the eastern end is a complete pulp and paper mill which is a small scale factory in itself. It contains a disc saw for slabs and chips, and two digesters, one rotary and one upright with respective capacities of 350 and 250 pounds of chips. The upright digester is lined with acid resisting brick and is equipped with valves, pressure gages and thermometers similar to those used in commercial practice. For sulphite acid liquors, there is a wooden tank with an agitator and pump. Attached to the digester is a lead-lined blow-off tank. There are two beaters for different kinds of paper stock, one a Jordan engine with a capacity of 100 pounds per hour, two stuff chests complete, and a combination Foudrinier and cylinder paper machine. The widest trimmed sheet which can be run through is 24 inches. The drying end of the machine contains 9 fifteen-inch driers with 32-inch face, and a calendar stack of 7 rolls of 7 inches diameter. Power is furnished by a 15-hp. motor for the beaters and the Jordan; a 5-hp. motor is attached to the constant speed end of the paper machine; while a 6-hp. variable speed motor provides power for the rest of it. One horsepower motors are used for agitators, pumps, etc. It really is a complete pulp and paper mill in which practically any kind of pulp or paper can be made.

At the western end of the basement is a considerable array of chemical apparatus for other work on a small factory scale. This includes tanks, vats, a diffusion battery, a luminous fractional tower and still and

parative fiber tests are made. For this purpose the samples are treated with the zinc chloride iodine stain, which colors ground wood pulp yellow, rag pulp red, and that of sulphite blue. Other fibers have their peculiar shapes and structural markings by which they are recognized under the microscope. Samples of fiber to be tested are checked against those of known content and the ratios are very closely approximated. Here and in the adjoining room for physical determination is a photomicrographic apparatus, a projectoscope, which is of great convenience for bringing the attention of several observers at once upon a problem, a polariscope, a Schopper paper tensile strength machine, a Schopper folder for measuring the resistance of paper to folding (two German instruments that should be made hereafter in America), Mullin strength testers which measure bursting strength in pound per square inch, Lloyd's hygrodeik (Taylor) that gives relative humidity to temperature for the control of tests, a privately designed apparatus for determining resistance of paper carton, etc., to bending, another original apparatus for determining the resistance of paper to tearing, a Perkins stretch tester and an Ives colorimeter.

The basement contains a room for crushing and grinding various substances. The mill for sampling coal is in a separate room, also in the basement. In another room is a rubber grinding machine; here are also located an emery wheel for polishing steel samples, a drill press for cutting them and a physical testing apparatus of 10,000 lb. capacity. The main stock room serves as a general store from which local stores of supplies on the second and third floors are furnished by means of a dumb-waiter. In the basement is a sample room, in which the original samples are kept for required periods. Another room (originally designed



GENERAL ANALYTICAL LABORATORY

other equipment. It is, like the paper mill, provided with an adjoining control laboratory.

A feature of great convenience is the relation of the general analytical to the research laboratories. Those engaged in research have their results tested and checked as often as they desire, which is naturally done far more expeditiously and accurately than if each research chemist had to rig up apparatus and make his own analyses. It was quite a venture to build this large establishment with such a great capacity, especially since it is a development to which industry has not as yet, in many respects, fully arrived.



## Book Reviews

**GENERAL CHEMISTRY.** By *Hamilton P. Cady, Ph.D.* Octavo, (14 x 20 cm.), xiv + 522 pages, 73 illustrations; price, \$2.25. McGraw-Hill Book Company, Inc.: New York. Hill Publishing Co., Ltd.: London.

This is an elementary book, an abridgment and simplification of the author's earlier book entitled "Inorganic Chemistry," intended for a shorter course. There is a large amount of material in the book, very well arranged. Chemical facts are presented in large numbers before discussions of chemical theories are introduced as attempted explanations of the facts. The text is very reliable, and the industrial information scattered through it is particularly well chosen and up to date (with the exception of the manufacture of boron by Weintraub's method, and of sodium by Von Kugelgen's process). Here and there a generalization is made too broad or a dictum laid down too tight, which is really serious because it misinforms the student and blunts the development of his scientific acumen. Such a case is the statement (p. 6) that it is a law that "if two bodies agree exactly in some few of their essential properties they will agree exactly in all and are composed of the same substance"; another (p. 27), that "whenever two or more substances combine to form another substance, they do so in a perfectly fixed and invariable ratio by weight." When the author revises this excellent book, he should carefully excise these illogical statements and imperfect generalizations. Otherwise there is hardly anything but praise to be expressed for the clearness and accuracy of presentation and method shown on almost every page of the book.

\* \* \*

**VAN NOSTRAND'S CHEMICAL ANNUAL.** By *John C. Olsen.* Fourth Issue, 778 pages. Price \$3.00. New York: D. Van Nostrand Company.

Since the 1913 issue the author has revised and added new material. The present volume has 161 tables of which 48 are new. The most authoritative chemical data on the physical constants of inorganic and organic compounds, alkaloids, essential oils, oils, fats, waxes, lubricating oils and gases are systematically treated. The standard tables of specific gravities of acids, bases, solutions and solvents are arranged in very legible form. The vapor tension of water and mercury, the equivalents of weights and measures, thermochemical data and the usual stoichiometrical and analytical data have highly satisfactory treatment. The special feature of this high grade book of tables is the chapter on stoichiometry by Prof. R. H. Ashley, in which a number of type problems are set and solved. These will be of great aid to many in becoming familiar with the application of the tables. A good catalog of technical books is included.

\* \* \*

**LABORATORY MANUAL OF BITUMINOUS MATERIALS.** By *Prévost Hubbard.* Octavo (14 x 23 cm.), xi + 153 pages, 39 illustrations; price, \$1.50. New York: John Wiley & Sons, Inc. London: Chapman & Hall, Ltd.

Intended as a laboratory guide for students of highway engineering, this treatise not only develops the abstract technique of the laboratory, but also deals with the interpretation of the results of tests, such as the suitability of the materials for specific purposes and control of uniformity of the materials in question. The testing is limited to the bituminous materials used in highway construction, and does not extend to the other materials, such as stone, gravel, sand, filler, wood, etc. used with the bitumen. The scope of the work is therefore very limited but in its field it is most excellently and practically written. It is too advanced and too specialized for the ordinary civil engineering student, but will be of great value to the graduate student specializing in highway construction and for all road-building specialists. One sole criticism is the use of "burning point" in place of "ignition point."

**THE CHEMIST'S POCKET MANUAL.** By *Richard K. Meade.* 530 pages. Price \$3.50. Easton, Pa.: Chemical Publishing Company.

The manual is a very condensed book printed in small type, covering a very wide scope in a brief manner. A table of contents should have been included as it would prove of great aid in familiarizing the readers of the book with the material. The 180 pages of technical analysis will prove valuable to those who do not have access to larger works or want a resumé on this subject. The tables do not equal other recent publications in the pure chemical field but treat many subjects not ordinarily found in these, a small amount of applied physics being included.

## Personal

**MR. L. G. E. BIGNELL**, formerly sales manager of the Denver office of Sutton, Steele & Steele, Inc., has been placed in charge of sales for the same company with offices in Dallas, Texas.

**MR. G. GRUNBERG** has recently severed his connection with the American Scientific Instrument Co. and has established his own business under the name of Scientific Utilities Company, Inc., which is located at 843 E. 10 St., N. Y. C.

**DR. A. E. KENNELLY**, acting head of the Department of Electrical Engineering at the Massachusetts Institute of Technology, has been called to Washington for special work with the Signal Corps. He expects to return to the Institute in the fall.

**MR. HENDERSON W. KNOTT**, formerly general manager of the Morgan Crucible Company of New York City, has been appointed by the United States Fuel Administration to manage the field force of engineers and inspectors who are at work among the power plants of the country. He will carry out a campaign of instruction and inspection to bring the use of fuel for the production of power to the highest possible efficiency and economy.

**DR. ARTHUR D. LITTLE**, of Arthur D. Little, Inc., Cambridge, was conferred the honorary degree of Doctor of Chemistry by the University of Pittsburgh at the commencement exercises on May 31, 1918.

**MR. A. NIEDERMAYER**, for many years connected with the Worthington Pump and Machinery Corporation, more recently as Works Manager of the Snow-Holly Works of that corporation, at Buffalo, N. Y., resigned on May 31 to devote his entire time to enterprises of his own.

**MR. DWIGHT P. ROBINSON** and **MR. JOHN W. HALLOWELL** retired from the firm of Stone & Webster on July 1, and the business will be continued by the remaining partners MESSRS. CHARLES A. STONE, EDWIN S. WEBSTER, RUSSELL ROBB, and HENRY G. BRADLEE. Mr. Robinson has been with Stone & Webster since 1893, from 1908 as president of the Stone & Webster Engineering Corporation and a member of the firm since 1912. Mr. Hallowell has been with Stone & Webster since 1901 and a member of the firm since 1912. Since May 1917, he has been in Washington with Mr. Hoover as a member of the United States Food Administration and expects to continue in that work for the duration of the war.

**MR. CHARLES B. SEEM** has become actively connected with the Electric Furnace Company in the capacity of sales engineer. He was formerly with Perin & Marshall, Consulting Engineers.

**DR. ALFRED STANSFIELD**, Professor of Metallurgy of McGill University, was recently in San Francisco conferring with officials of the Noble Electric Company. Dr. Stansfield has been retained by the provincial government of British Columbia to report upon the possibilities of establishing an electric iron and steel industry in that region.

THE UNITED STATES FUEL ADMINISTRATION announces the appointment of administrative engineers as follows: THOMAS R. BROWN, Pittsburgh; for the western half of

Pennsylvania. He was formerly special engineer with the Westinghouse Air Brake Company. GEORGE R. HENDERSON, Philadelphia; for the eastern half of Pennsylvania. He was formerly consulting engineer with the Baldwin Locomotive Works. EDWARD N. TRUMP, New York; for the state of New York. He has been the vice president of the Solvay Process Company. W. R. C. CORSON, Hartford; for New England. He has been actively engaged in practice as a consulting engineer.

MR. H. S. WETZEL, formerly chief chemical engineer of the Pittsburgh-Butte Coal Co., has resigned to accept a position with the National Carbon Company of Niagara Falls, N. Y.

## Obituary

MR. ROBERT BROWN CARNAHAN, JR., vice president of The American Rolling Mill Co., was killed in an accident on June 22, 1918. After graduating from the University of Pittsburgh in 1891, Mr. Carnahan was actively associated with the Dewees-Wood Company at McKeesport, Pa. from 1893 to 1899, when he went to the Homestead Works of the Carnegie Steel Co., soon after which he went into the present central works of The American Rolling Mill Co. as chief chemist and open hearth superintendent. It was under Mr. Carnahan's direction that Armco American Ingot Iron was developed. Mr. Carnahan was a member of The American Iron and Steel Institute, The American Institute of Mining Engineers and The American Society For Testing Materials. His alma mater conferred the honorary degree of Doctor of Science upon him in 1912.

DR. EDGAR MARBURG, secretary-treasurer of The American Society for Testing Materials, and professor of Civil Engineering in the University of Pennsylvania, died June 27, 1918, the news of his death being received during the twenty-first meeting of the Society.

## Current Market Reports

### Non-Ferrous Metal Market

**Monday, July 8:**—Prices have a tendency to rise due to the 25% freight rate increase.

**Aluminium:**—The government price is 30c. a pound f.o.b. plant in 50-ton lots, 33.1c. down to 15-ton lots, and 33.2c. in lots down to 1 ton, 40c. to 45c. for smaller lots.

**Antimony:**—Demand is quiet but large orders are expected. Spot antimony, duty paid, is quoted at 13c. to 13½c.

**Chrome:**—Producers have established a schedule on the basis of \$1.30 per unit ore; some 40% ore has sold for \$1.50 per unit.

**Copper:**—The price has been advanced to 26c., an increase of 2½c., about one-half of which is to go to an increased refinery rate.

**Lead:**—The basic fixed price at East St. Louis is 7½c. New York is short and prices vary from 8.05c. to 8.25c.

**Manganese:**—Variable ton unit scale price, 40 per cent \$1.10, 50 per cent \$1.20. For full specifications see Metallurgical and Chemical Engineering, page 629, June 15.

**Manganese:**—Variable ton unit scale price: 40%, \$1.10; 50%, \$1.20. For full specifications see METALLURGICAL AND CHEMICAL ENGINEERING, page 629, June 15.

**Molybdenum:**—Quoted at \$1.25 per pound for 90% molybdenum sulphide.

**Silver:**—Sixty-four million silver dollars have been melted into bullion by the U. S. Treasury, for export to India. The Treasury still holds 426,000,000 silver dollars, against which \$390,000,000 silver certificates are outstanding. Silver is quoted at 99% c. per troy ounce.

**Spelter:**—Buying not heavy. Prime western is quoted at New York at 8.67½c. to 8.87½c. for July; at East St. Louis, 8½c. to 8% c., futures to October 8.55c. to 8.80c.

**Tin:**—Conservative buying. At Coast, Banca is offered at 91c. At New York, Lamb and Flagg at 94c., Straits for August shipment at 87½c. Large consumers importing direct.

**Tungsten:**—The highest grade material containing no tin, no copper, low manganese and over 70% WO<sub>3</sub>, has brought \$24.00 per ton unit. Impure material has sold as low as 95c. per pound WO<sub>3</sub> contained.

|                        |          |        |
|------------------------|----------|--------|
| Bismuth .....          | \$3.50   |        |
| Cadmium .....          | \$1.40   | — 1.50 |
| Nickel .....           | \$0.40   | — .43  |
| Platinum oz. ....      | \$1.05   |        |
| Palladium oz. ....     | \$1.35   |        |
| Cobalt .....           | \$2.50   | — 3.50 |
| Magnesium .....        | \$1.75   | — 2.00 |
| Quicksilver .....      | \$125.00 |        |
| California (75 lb.) .. | \$115.00 |        |
| Mexican (75 lb.) ..    | \$118.00 |        |

### The Iron and Steel Market

While the stiff freight rate advance of June 25 bears very heavily upon the merchant blast furnaces, particularly as the advance of 45 cents a ton in Lake Superior ore allowed by the War Industries Board passes the rate advance on Lake Superior ore on to the blast furnaces, the chief complaint of blast furnaces that there is too little margin between costs and the permissible maximum selling prices, or no margin at all, comes from furnaces in Tennessee and Virginia, and arises largely from quite unsatisfactory labor performance. The effect upon negro labor of successive wage advances has been particularly unfortunate, as to make living expenses it is quite unnecessary to work full time, and the men sometimes work as few as two days a week, interfering sadly with full operation, while performance when on duty is far below standard. There are various other difficulties, but the matter of labor presents the most serious problem. While a few of the furnaces have been advocating a higher selling price, it is the common opinion that the matter must be approached from some other angle. The American Pig Iron Association has held two general meetings on the subject, the details of the discussion not being made public.

### PROFITS AND TAXATION

The steel manufacturers as a whole are well satisfied with the price situation, as with few exceptions the allowed prices afford very comfortable profits. The manufacturers are concerned chiefly with production, being anxious to have full output in order to meet fully all the desires of the Government and incidentally to keep down costs, which mounted very seriously last January and February, with the average of 55 to 60 per cent operation which obtained in those months.

There has been a little criticism in some quarters of the report the Federal Trade Commission recently made to the Senate as to profits in various industries, and it is evident that the critics did not digest the report or they would have been able to find no reasonable fault with the references to the iron and steel industry. The Senate called for the report, by resolution, for the double purpose of securing information that would be helpful in the taxation program and of receiving light on how profiteering might be regulated by law. As to the latter phase of the general inquiry the Federal Trade Commission could make no reference in the case of iron and steel, for the reason that all iron and steel prices are controlled strictly by the War Industries Board, under approval of the President, and the regulating authorities are well satisfied with the situation. The Federal Trade Commission, moreover, has an important voice in the settling of iron and steel prices, the War Industries Board depending largely upon its findings as to costs, and also upon its judgment. As a matter of fact the report in question made absolutely no attempt to criticize the existing iron and steel prices. The report did show that the industry as a whole is making very large profits, but as Congress is seeking profits for the purpose of taxing them, with an eight billion dollar revenue program before it, the reference was decidedly fitting. The report did not criticize the iron and steel industry in any respect. The "meat trust" on the other hand was scored severely, while the accounting and other methods employed by some industries that are allowed a margin above cost, particularly the flour milling industry, were severely criticized. At-



tention was directed to the fact that in industry in general there are many instances of wide divergencies in cost, whereby a given price may afford one manufacturer a small profit and another a large profit, this being distinctly suggestive of the desirability of a general policy of having relatively high prices and of taxing excess profits very heavily. On the whole the report furnishes some ground for expectation that there will not be much effort made to reduce iron and steel prices, while excess profits will be heavily taxed.

#### LABOR AND PRODUCTION

It is becoming increasingly clear that in the matter of production it is not so much a question of the number of workmen available as a whole as it is a question of their performance. The Government is insisting that after August 1 employers engaged in war work shall recruit labor through no channel but the federal employment offices organized by the Department of Labor. There has been much waste of labor through labor recruiting methods which may have benefited the employers who practiced them, but certainly injured other employers. The iron and steel producers feel that they have suffered much more than they have benefited from the recruiting of labor by the payment of bonuses, and other unusual methods, and hopes for better conditions when the federal employment system is made the sole means of employing labor.

#### SOLUTION OF PROBLEM

The American Sheet & Tin Plate Company has put into operation a system of its own devising for stimulating activity among its employes, and finds even the first experience in this connection very satisfactory, definite and valuable results being observed within the first fortnight of the system's application. The first operation was to post notices at all the company's plants, 13 sheet plants and 14 tin plate plants, to the effect that all employes would be solicited to sign a pledge for 100 per cent. efficiency. The men became interested at once, and began calling for the pledge cards, which were being prepared as rapidly as possible. Each card carries the pledge in English and in some foreign language. The workman signs the pledge card and returns it to the manager. A record is made and the signed pledge is returned to the man, who knows that the company has a record of his having signed the pledge, which obligates him: (1) Not to absent himself from work except when absolutely necessary; (2) to work faithfully when on duty; (3) to make every effort to induce his fellow workmen to do likewise. There is a series of four buttons, each with the inscription "100 per cent efficiency man," white upon signing the pledge, red upon keeping it for 30 days, blue for 60 days and red, white and blue for 90 days, the 90-day service involving also a "service certificate." The idea took hold so well that men began forming "efficiency clubs" providing a fine of \$1, to go to the Red Cross, for avoidable absence. The company employs men speaking 59 languages, only a fraction of this number being represented at any one plant. A record of attendance at work is kept, quite apart from the payroll, and each case of absence is investigated, unavoidable absences being excused.

#### DISTRIBUTION

Supplies of merchant pig iron and of steel are in the main not sufficient to cover entirely the preference list, after direct and indirect government orders are satisfied, and as a result scarcely any material is being distributed to the general trade, not accorded any preference. The preference uses, however, are so numerous that there are but few requirements of a general commercial character not covered. Buyers not entitled to preference, moreover, have some stocks of material and supplies may become available for them before present stocks are exhausted. The war activities are in many cases receiving more material than is currently consumed, this being in accordance with the desire of the Director of Steel Supply, that surpluses be accumulated, particularly in connection with shipbuilding and shell manufacture, to provide against possible curtailment in production and shipments next winter. The

manufacture and consumption of steel for war purposes is proceeding in a very satisfactory manner.

#### STRUCTURAL STEELS.

|                                            |               |
|--------------------------------------------|---------------|
| Tank Plates, Sheets, etc., per ton         | 70.00—80.00   |
| Beams, Channels, Z's, T's, L's, wire, etc. | 65.00—85.00   |
| Rivets, Spikes, Rails, etc.                | 88.00—100.00  |
| Tin Plate, Tern, etc.                      | 150.00—155.00 |
| Galvanized Sheets, etc.                    | 104.00—135.00 |

#### Chemical Market

**HEAVY CHEMICALS:**—In general the period of the last two weeks has been very quiet but marked by some little activity in caustic soda which is considered the barometer of conditions of the present. There developed considerable call for sodium sulphide, saccharine and calcium carbide but as is usual under a heavy inquiry, stocks were very meagre.

**Trisodium Phosphate:** For material in carload lots interests are quoting 5c per pound f.o.b. New York with smaller quantities available at 5½c. Inquiry was not active and although stocks are not heavy there apparently is confidence in ability to supply the demand. There is also material at hand available for export.

**Caustic Soda:** The situation is causing considerable comment and the unusually quiet conditions prevailing do not seem to indicate any improvement for the near future at least. Material rolling to New York is thought to amount to a rather important tonnage and buyers are seemingly fully aware of this situation and are awaiting developments before attempting to enter the market. Some stocks were held as low as 3.80 and 3.90 rolling, but generally these were brands not in particular favor. For standard brands such as 76 from 4.15 to 4.30 is being asked ex-store New York.

**Soda Ash:** The dense material has been very hard to locate but has been in strong demand for Western shipment with prices quoted at 3.80 f.o.b. Western works. The light ash is being offered at from 2.10 to 2.15 in bags, spot New York and at from 2.80 to 2.85 in barrels and up to 2.90 in some instances.

**Sulphuric Acid:** The notable feature on this item and of great moment to the trade was the definite announcement from Washington that the War Trade Board has definitely fixed the maximum trading levels for acids. The 66 degree material is fixed at \$28.00 f.o.b. works in sellers tanks. The 60 degree material is to sell at a maximum level of \$18.00 same basis. The basis for fuming acid, 20% oleum is \$32.00 per ton. In carboy carload lots one-half cent per pound extra is allowed and in carboys less than carloads three quarters of a cent per pound extra is allowed. In drums any quantity one-half cent per pound extra is allowed. So far the trade is without more definite advices and until the ruling in detail is explained matters will be rather complicated. It has been made plain however that the price setting is not to be retroactive and that contracts now in effect or those which have not yet been completed, will not be affected unfavorably.

**Nitric Acid:** Forty-two degrees Baumé 8½c per pound, f.o.b. manufacturers' works in carboys. Other strengths of nitric acid based upon the above prices are as follows:

|             |                  |                    |
|-------------|------------------|--------------------|
| Nitric Acid | 36 degrees Baume | \$0.0650 per pound |
| Nitric Acid | 38 degrees Baume | .0715 per pound    |
| Nitric Acid | 40 degrees Baume | .0775 per pound    |
| Nitric Acid | 42 degrees Baume | .0850 per pound    |
| Nitric Acid | 43 degrees Baume | .0890 per pound    |

A schedule of prices on mixed acids is being prepared and will be published later.

The above maximum prices are agreed upon for the public, as well as for Government purchases. It is understood and agreed that any deliveries made after September 30th will be subject to any revision in price which the Government may make for deliveries after that date. The above prices do not in any way interfere with contracts now in effect and which have not yet been completed. It is understood that carboys are to be invoiced as shipments are made, and credit issued when returned in good order.

**Pernmanganate of Potash:** Prices asked for spot material are holding steady although the market has been quiet, in general with most other items. The U. S. P. material is ranging from 2.50 to 2.60 per pound and about 2.25 to



2.30 for the technical grade. For the U. S. P. on contract there is concession to the extent of from ten to twenty-five cents.

**Sal Ammoniac:** With the diminishing of supplies the tendency has been for the raising of the asking price and it has been noted that a considerable quantity of the gray material has been passed at 22c, rolling. There has been a very steady demand.

**COAL TAR PRODUCTS:** The general tendency in this market has been toward an advance in prices although things have been rather quiet particularly in the latter part of the two weeks period owing to the holiday. One of the most notable occurrences was the direct reversal of relations between the two saccharines.

**Phenol:** There are many conflicting rumors concerning supply, demand, exports and imports and also with regard to governmental attitude; but as near as it is possible at present to gain them the facts appear to be that there is a very small unsold or uncontracted-for supply of phenol available today. The demand has been very good; export licenses are continuing to be granted and there is some mystification as to the reasons for the importations of the English phenol, arrivals of which have been reported as there is for even the offerings which are known to have been made, because of the undoubted requirements of the British Government itself for this product. The question remains unanswered as does also the one with regard to exportations from this country when it is known that although the U. S. Government has contracted for all requirements up to date they are placing large contracts for future deliveries of millions of pounds to take care of estimated monthly needs and still are not confident that the production will keep pace with the growing need for and production of picric acid. It is felt however that such government orders do not have a direct affect upon the resale market. Sales have been made of large quantities at 44c which is very close to that which the English material would bring with all duties paid. General quotations on resale continue at, and the market is judged to be from, 45 to 48c.

**Paranitraniline:** Inquiry on this item has been very good but material is said to be scarce and holders few. Those who have material to offer are doing so in very small quantities. Prices show a tendency to advance as some holders are asking ten cents more on the small lots offered than was asked a few days ago. Actual sales are reported of five barrel quantities at 1.85.

**H-Acid:** Production is centered in a few hands and the demand has evidently absorbed the supplies for July as factors are reticent about quoting on material for earlier than August shipment. The prices quoted show a tendency toward a rise as 2.60 is now the lowest heard and in some directions there is refusal to accept less than 2.75. For the highest grades however no quotations have yet been heard in excess of 3.00.

**Saccharines:** The soluble material has been in extraordinary demand with holders hard to locate. Relations as to price and demand have reversed themselves as between the two grades in that the soluble has actually passed at 29.00 and 30.00 with the insoluble now at from 22.00 to 23.00.

**Dinitrophenol:** Quotations on material for shipment f.o.b. works run from 55 to 60c according to quantity. Supplies are said to be available to cover all needs at least in the present state of the market as the inquiry for this product is but fair and actual sales but few.

**Monochlorbenzol:** Some factors are completely sold up on stocks for the balance of the year on contract but from certain sources plenty of the product is obtainable at the prices of from 17 to 19c according to quantity desired. Inquiry however has been slow.

**Benzoate of Soda:** Prices for the soda continue to be quoted at from 3.00 to 3.25 and for the acid at from 3.45 to 3.70, however, it is rumored that both of these products are to be advanced in the near future as the prices at which they have been holding are so close to manufacturing cost as to not permit of profitable business on present demands.

## General Chemicals

WHOLESALE PRICES IN NEW YORK MARKET, JULY 8, 1918

|                                                 |         |               |         |
|-------------------------------------------------|---------|---------------|---------|
| Acetic anhydride                                | lb.     | 1 60          | 1.85    |
| Acetone, drums                                  | lb.     | Nominal       |         |
| Acid, acetic, 28 per cent                       | lb.     | Nominal       |         |
| Acetic, 56 per cent                             | lb.     | Nominal       |         |
| Acetic, glacial, 99 1/2 per cent, carboys       | lb.     | Nominal       |         |
| Boric crystals                                  | lb.     | 184           | .15     |
| Citric crystals                                 | lb.     | 82            | .88     |
| Hydrochloric, C. P.                             | lb.     | Nominal       |         |
| Hydrochloric, 20 deg.                           | lb.     | .02           | .02 1/2 |
| Hydrochloric, conc., 22 deg.                    | lb.     | .02 1/2       | .03 1/2 |
| Hydrofluoric, 30 per cent in barrels            | lb.     | .06           | .06 1/2 |
| Lactic, 44 per cent                             | lb.     | .15           | .16     |
| Lactic, 22 per cent                             | lb.     | .06           | .07     |
| Molybdenic, C. P.                               | lb.     | 6 90          | 7.40    |
| Nitric, 36 deg.                                 | lb.     | Nominal       |         |
| Nitric, 42 deg.                                 | lb.     | .03 1/2       | .10     |
| Oxalic, crystals                                | lb.     | .08           | .45     |
| Phosphoric, 47-50 per cent paste                | lb.     | .08           | .10     |
| Phosphoric, ref. 50 per cent                    | lb.     | .33           | .40     |
| Picric                                          | lb.     | Nominal       |         |
| Pyrogallol, resublimed                          | lb.     | 3 10          | 3.15    |
| Sulphuric, 60 deg.                              | ton     | Nominal       |         |
| Sulphuric, 66 deg.                              | ton     | Nominal       |         |
| Sulphuric, oleum (Fuming), tank cars            | ton     | Nominal       |         |
| Tannic, U. S. P., bulk                          | lb.     | 1 40          | 1.45    |
| Tartaric crystals                               | lb.     | .86           | .89     |
| Tungstic, per lb. of W                          | lb.     | 1 70          | 1.75    |
| Alcohol, sugar cane, 188 proof                  | gal.    | 4 89          | 4.90    |
| Alcohol, wood, 95 per cent                      | gal.    | .90 1/2       | .91     |
| Alcohol, denatured, 180 proof                   | gal.    | .67           | .68     |
| Alum, ammonia lump                              | lb.     | .04           | .04 1/2 |
| Alum, chrome ammonium                           | lb.     | .18           | .19     |
| Alum, chrome potassum                           | lb.     | .20           | .21     |
| Alum, chrome sodium                             | lb.     | .12 1/2       | .13     |
| Alum, potash lump                               | lb.     | .08           | .09     |
| Aluminium sulphate, technical                   | lb.     | .02 1/2       | .03     |
| Aluminium sulphate, iron free                   | lb.     | .03           | .04     |
| Ammonia aqua, 26 deg., carboys                  | lb.     | (Fixed Price) |         |
| Ammonia, anhydrous                              | lb.     | 15            | Nominal |
| Ammonium carbonate                              | lb.     | 15            | .16     |
| Ammonium nitrate                                | lb.     | (Fixed Price) | .15     |
| Ammonium sulphate domestic                      | lb.     | .07 1/2       | .08     |
| Amyl acetate                                    | gal.    | 5 15          | 5.25    |
| Arsenic, white                                  | lb.     | .04 1/2       | .17     |
| Arsenic, red                                    | lb.     | .65           | .70     |
| Barium carbonate, 99 per cent                   | ton     | 80.00         | 90.00   |
| Barium carbonate, 97-98 per cent                | ton     | 65.00         | 67.00   |
| Barium chloride                                 | ton     | 65.00         | 70.00   |
| Barium sulphate (Blanc Fixe, Dry)               | lb.     | .04 1/2       | .05     |
| Barium nitrate                                  | lb.     | .10           | .11     |
| Barium peroxide, 70-75 per cent                 | lb.     | .30           | .32     |
| Bleaching powder, 35 per cent chlorine          | lb.     | .02           | .03     |
| Borax, crystals, sacks                          | lb.     | .07 1/2       | .08 1/2 |
| Brimstone, crude                                | ton     | Nominal       |         |
| Bromine, technical                              | lb.     | .75           | Nominal |
| Calcium, acetate, crude                         | lb.     | Nominal       |         |
| Calcium, carbide                                | lb.     | .15           | .16     |
| Calcium chloride, 70-75 per cent, fused, lump   | ton     | 22.00         | 24.00   |
| Calcium peroxide                                | lb.     | 1 60          | 1.70    |
| Calcium phosphate                               | lb.     | .22           | .23     |
| Calcium sulphate 98-99 per cent                 | lb.     | .09           | .09 1/2 |
| Carbon bisulphide                               | lb.     | .08 1/2       | .09     |
| Carbon tetrachloride, drums                     | lb.     | 1 10          | 1.18    |
| Carbonyl chloride (phosgene)                    | lb.     | 1 10          | 1.50    |
| Caustic potash, 88-92 per cent                  | lb.     | 4 00          | 4.25    |
| Caustic soda, 76 per cent                       | 100 lb. | 4 00          | 4.25    |
| Chlorine, liquid                                | lb.     | (Fixed Price) | .07 1/2 |
| Cobalt oxide                                    | lb.     | 1 60          | 1.65    |
| Copperas                                        | lb.     | .01 1/2       | .32     |
| Copper carbonate                                | lb.     | .75           | .78     |
| Copper cyanide                                  | lb.     | .08 1/2       | .09 1/2 |
| Copper sulphate, 99 per cent, large crystals    | lb.     | .77           | .78     |
| Cream of tartar, crystals                       | lb.     | 3 62 1/2      | 3.90    |
| Epsom salt, bulk, U. S. P.                      | lb.     | 16 1/2        | 17 1/2  |
| Formaldehyde, 40 per cent                       | 100 lb. | 1 50          | 1.75    |
| Glauber's salt                                  | lb.     | .62           | .65     |
| Glycerine, bulk, C. P.                          | lb.     | 4 25          | 4.30    |
| Iodine, resublimed                              | lb.     | .13           | .15     |
| Iron oxide                                      | lb.     | .17           | .18     |
| Lead acetate, white crystals                    | lb.     | .15           | .18     |
| Lead arsenate (Paste)                           | lb.     | .15           | Nominal |
| Lead nitrate                                    | lb.     | Nominal       |         |
| Litharge, American                              | lb.     | 1 01          | 1.23    |
| Lithium carbonate                               | lb.     | 1 50          | 2.00    |
| Manganese dioxide, U. S. P.                     | lb.     | .70           | .75     |
| Magnesium carbonate, technical                  | lb.     | .21           | .23     |
| Nickel salt, single                             | lb.     | .14           | .15     |
| Nickel salt, double                             | lb.     | .12           | .14     |
| Phosgene, gas, Carbonyl chloride                | lb.     | 1 20          | 1.30    |
| Phosphorus, red                                 | lb.     | 1 00          | 1.25    |
| Phosphorus, yellow                              | lb.     | .46           | .47     |
| Potassium bichromate                            | lb.     | 3 15          | 3.50    |
| Potassium bromide, red                          | lb.     | 40            | 50      |
| Potassium carbonate calcined, 85-90 per cent    | lb.     | 38            | 40      |
| Potassium chlorate, crystals                    | lb.     | Nominal       |         |
| Potassium cyanide, 98-99 per cent               | lb.     | 3 75          | 3.80    |
| Potassium iodide                                | ton     | 300 00        | 350 00  |
| Potassium muriate 80-85 p. c. basis of 80 p. c. | lb.     | .27           | .31     |
| Potassium nitrate                               | lb.     | 2 50          | 3.65    |
| Potassium permanganate (U. S. P.)               | lb.     | 1 80          | 2.90    |
| Potassium prussiate, red                        | lb.     | 1 10          | 1.20    |
| Potassium prussiate, yellow                     | ton     | Nominal       |         |
| Potassium sulphate, 90-95 p. c. basis 90 p. c.  | lb.     | 44 1/2        | 46      |
| Rochelle salt                                   | lb.     | .22           | .23     |
| Salammoniac, gray gran                          | lb.     | .20           | .21     |
| Salammoniac, white gran                         | lb.     | 1 35          | 1.40    |
| Salt soda                                       | 100 lb. | 30 00         | 35 00   |
| Salt cake                                       | ton     | 30 00         | 35 00   |
| Silver cyanide, based on market price of silver | oz.     | .62 1/2       | .63     |
| Silver nitrate                                  | 100 lb. | 2 10          | 2.15    |
| Soda ash, 56 per cent, light, flat (bags)       | 100 lb. | 3 65          | 4.00    |
| Soda ash, 56 per cent, dense, flat              | lb.     | Nominal       |         |
| Sodium bicarbonate, domestic                    | lb.     | .03           | .03 1/2 |
| Sodium bicarbonate, English                     | lb.     | .27 1/2       | .29     |
| Sodium bichromate                               | lb.     | 27 1/2        | 29      |

|                                        |         |      |         |      |
|----------------------------------------|---------|------|---------|------|
| Sodium bisulphite, powd                | lb.     | 06   | —       | 063  |
| Sodium chlorate                        | lb.     | 24   | —       | 25   |
| Sodium cyanide                         | lb.     | 17   | —       | 42   |
| Sodium fluoride, commercial            | lb.     | 40   | —       | 18   |
| Sodium hyposulphite                    | lb.     | 2 40 | —       | 2 50 |
| Sodium molybdate, per lb. of Mo        | lb.     | 2 50 | —       | —    |
| Sodium nitrate, 95 per cent            | 100 lb. | 28   | Nominal | 30   |
| Sodium nitrite                         | lb.     | 35   | —       | 45   |
| Sodium peroxide                        | lb.     | 04   | —       | 05   |
| Sodium phosphate                       | lb.     | 60   | —       | 63   |
| Sodium prussiate, yellow               | lb.     | 06   | Nominal | —    |
| Sodium silicate, liquid (60 deg.)      | lb.     | —    | Nominal | —    |
| Sodium sulphide, 30 per cent, crystals | 100 lb. | —    | Nominal | —    |
| Sodium sulphate, 60 per cent, fused    | 100 lb. | —    | Nominal | —    |
| Sodium sulphate                        | lb.     | 25   | —       | 35   |
| Strontium nitrate                      | lb.     | 06   | —       | 063  |
| Sulphur chloride, drums                | lb.     | 15   | —       | 40   |
| Sulphur dioxide, liquid, in cylinders  | 100 lb. | 4 05 | —       | 4 60 |
| Sulphur, flowers, sublimed             | 100 lb. | 3 70 | —       | 3 85 |
| Sulphur, roll                          | ton     | —    | Nominal | —    |
| Sulphur, crude                         | lb.     | 28   | —       | 29   |
| Tin bichloride, 50 deg.                | lb.     | 1 00 | —       | 1 25 |
| Tin oxide                              | lb.     | 22   | —       | 15   |
| Zinc carbonate                         | lb.     | 15   | —       | 18   |
| Zinc chloride                          | lb.     | —    | Nominal | —    |
| Zinc cyanide                           | lb.     | 14   | —       | 16   |
| Zinc dust, 350 mesh                    | lb.     | 13   | —       | 14   |
| Zinc oxide, American process XX        | lb.     | 05   | —       | 06   |
| Zinc sulphate                          | lb.     | —    | —       | —    |

### Coal Tar Products (Crude)

|                                        |      |      |               |       |
|----------------------------------------|------|------|---------------|-------|
| Benzol, pure, water white              | gal. | 23   | —             | 28    |
| Benzol, 90 per cent                    | gal. | —    | (Fixed Price) | 1 50  |
| Toluol, in tank cars                   | gal. | —    | (Fixed Price) | 1 55  |
| Toluol, for non-military use, in drums | gal. | 45   | —             | 55    |
| Xylol, pure, water white               | gal. | 18   | —             | 28    |
| Solvent naphtha, water white           | gal. | 12   | —             | 15    |
| Solvent naphtha, crude, heavy          | gal. | 39   | —             | 40    |
| Cresote oil, 25 per cent               | gal. | 30   | —             | 32    |
| Dip oil, 20 per cent                   | ton  | 8 00 | —             | 20 00 |
| Pitch, various grades                  | lb.  | 1 05 | —             | 10    |
| Carbolic acid, crude, 95-97 per cent   | lb.  | 1 60 | —             | 65    |
| Carbolic acid, crude, 90 per cent      | lb.  | 35   | —             | 38    |
| Carbolic acid, crude, 25 per cent      | lb.  | 18   | —             | 20    |
| Cresol, U. S. P.                       | lb.  | —    | —             | —     |

### Intermediates, Etc.

|                                 |     |       |         |       |
|---------------------------------|-----|-------|---------|-------|
| Alpha naphthol, crude           | lb. | 1 00  | —       | 1 10  |
| Alpha naphthol, distilled       | lb. | 1 60  | —       | 1 70  |
| Alpha naphthylamine             | lb. | 60    | —       | 65    |
| Aniline oil, drums extra        | lb. | 27    | —       | 28    |
| Aniline salts                   | lb. | 34    | —       | 36    |
| Anthracene, 80 per cent         | lb. | 3 65  | Nominal | —     |
| Benzaldehyde (f. c.)            | lb. | 1 75  | —       | 2 00  |
| Benzidine, base                 | lb. | 1 40  | —       | 1 50  |
| Benzidine, sulphate             | lb. | 3 40  | —       | 3 60  |
| Benzic acid, U. S. P.           | lb. | 3 00  | —       | 3 25  |
| Benzozate of soda, U. S. P.     | lb. | 2 30  | —       | 2 50  |
| Benzyl chloride                 | lb. | 10 00 | —       | 12 00 |
| Beta naphthol, nzoate           | lb. | 85    | —       | 90    |
| Beta naphthol, sublimed         | lb. | 2 65  | —       | 2 80  |
| Beta naphthylamine, sublimed    | lb. | 15    | —       | 20    |
| Dichlor benzol                  | lb. | 4 50  | —       | 5 00  |
| Diethylaniline                  | lb. | 36    | —       | 38    |
| Dinitro benzol                  | lb. | 40    | —       | 42    |
| Dinitrochlorobenzol             | lb. | 60    | —       | 70    |
| Dinitronaphthalene              | lb. | 65    | —       | 75    |
| Dinitrotoluol                   | lb. | 46    | —       | 50    |
| Dinitrophenol                   | lb. | 75    | —       | 80    |
| Dimethylaniline                 | lb. | 75    | —       | 80    |
| Diphenylamine                   | lb. | 2 60  | —       | 3 00  |
| Hydroquinone                    | lb. | 1 75  | —       | 2 00  |
| Metanaphthylendiamine           | lb. | 17    | —       | 20    |
| Monochlorobenzol                | lb. | 083   | —       | 093   |
| Naphthalene, flake              | lb. | 10    | —       | 103   |
| Naphthalene, balls              | lb. | 1 20  | —       | 1 30  |
| Naphthalene, acid, crude        | lb. | 1 00  | —       | 1 10  |
| Naphthylamine-di sulphonic acid | lb. | 45    | —       | 50    |
| Nitro naphthalene               | lb. | 60    | —       | 65    |
| Nitro toluol                    | lb. | 15    | —       | 18    |
| Ortho-amidophenol               | lb. | 1 00  | —       | 1 25  |
| Ortho-dichlorobenzol            | lb. | 7     | —       | 100   |
| Ortho-toluidine                 | lb. | 4 00  | —       | 4 50  |
| Ortho-nitro-tolol               | lb. | 4 00  | —       | 5 00  |
| Para-amidophenol, base          | lb. | 15    | —       | 20    |
| Para-amidobenzol, H. Cl.        | lb. | 1 60  | —       | 1 85  |
| Para-dichlorobenzol             | lb. | 1 50  | —       | 1 60  |
| Paranitraniline                 | lb. | 3 75  | —       | 4 00  |
| Para-nitro-tolol                | lb. | 2 00  | —       | 2 25  |
| Paraphenylendiamine (base)      | lb. | 3 50  | —       | 4 00  |
| Para-toluidine                  | lb. | 3 4   | —       | 40    |
| Phthalic anhydride              | lb. | 5 00  | —       | 7 00  |
| Phenol, U. S. P.                | lb. | 8 00  | —       | 9 00  |
| Resorcin, technical             | lb. | 1 10  | —       | 1 20  |
| Resorcin, pure                  | lb. | 1 50  | —       | 2 00  |
| S. lievin's acid                | lb. | 30    | —       | 32    |
| Sulphanilic acid, crude         | lb. | 2 50  | —       | —     |
| Tolidin                         | lb. | 85    | —       | 90    |
| Toluidine-mixture               | lb. | —     | —       | —     |

### Petroleum Oils

(Crude (at the Wells))

|                        |      |      |   |   |
|------------------------|------|------|---|---|
| Pennsylvania           | bbl. | 4 00 | — | — |
| Corning, Ohio          | bbl. | 2 85 | — | — |
| Somerset, Ky.          | bbl. | 2 60 | — | — |
| Wooner, Ohio           | bbl. | 2 68 | — | — |
| Indiana                | bbl. | 2 42 | — | — |
| Illinois               | bbl. | 2 25 | — | — |
| Oklahoma and Kansas    | bbl. | 2 25 | — | — |
| Caddo, La., light      | bbl. | 2 25 | — | — |
| Corsicana, Tex., light | bbl. | 2 25 | — | — |

|                      |      |      |   |      |
|----------------------|------|------|---|------|
| California           | bbl. | 1 24 | — | 1 57 |
| Gulf Coast           | bbl. | 1 35 | — | —    |
| Fuel Oil             |      |      |   |      |
| New York             | gal. | 15   | — | —    |
| Pittsburgh           | gal. | 074  | — | 10   |
| Oklahoma-Kans.       | bbl. | 1 05 | — | 2 75 |
| Texas                | bbl. | 1 85 | — | 2 35 |
| Los Angeles          | bbl. | 1 60 | — | —    |
| San Francisco        | bbl. | 1 60 | — | —    |
| Gasoline (Wholesale) |      |      |   |      |
| New York             | gal. | 24   | — | —    |
| Boaton               | gal. | 25   | — | —    |
| Pittsburgh           | gal. | 28   | — | —    |
| Chicago              | gal. | 224  | — | —    |
| Oklahoma             | gal. | 25   | — | —    |
| San Francisco        | gal. | 20   | — | —    |

### Lubricants

|                                             |      |    |   |    |
|---------------------------------------------|------|----|---|----|
| Black, reduced, 29 gravity, 25-30 cold test | gal. | 23 | — | 24 |
| Cylinder, light                             | gal. | 38 | — | 39 |
| Cylinder, dark                              | gal. | 35 | — | 36 |
| Paraffine, high viscosity                   | gal. | 40 | — | 41 |
| Paraffine, 903 sp. gr.                      | gal. | 36 | — | 38 |
| Paraffine, 885 sp. gr.                      | gal. | 26 | — | 28 |

### Flotation Oils

(Prices at New York unless otherwise stated)

|                                                                     |      |    |   |    |
|---------------------------------------------------------------------|------|----|---|----|
| Pine oil, crude, f. o. b. Florida                                   | gal. | 44 | — | —  |
| Pine oil, steam-distilled, sp. gr. 0.925-0.940                      | gal. | 58 | — | 60 |
| Pine oil, destructively distilled                                   | gal. | 58 | — | 60 |
| Pine-tar oil, sp. gr. 0.870-0.900                                   | gal. | 35 | — | —  |
| Pine-tar oil, double refined, sp. gr. 0.965-0.990                   | gal. | 42 | — | —  |
| Pine-tar oil, ref., light, sp. gr. 0.950, tank cars, f. o. b. works | gal. | 37 | — | —  |
| Pine-tar oil, ref., heavy, sp. gr. 1.025, tank cars, f. o. b. works | gal. | 28 | — | —  |
| Pine-tar oil, ref., thin, sp. gr. 1.060-1.080                       | gal. | 32 | — | —  |
| Turpentine, crude, sp. gr. 0.870-0.900                              | gal. | 45 | — | —  |
| Hardwood oil, f. o. b. Michigan, sp. gr. 0.960-0.990                | gal. | 23 | — | —  |
| Hardwood oil, f. o. b. Michigan, sp. gr. 1.06-1.08                  | gal. | 23 | — | —  |
| Wood creosote, ref. f. o. b. Florida                                | gal. | 31 | — | —  |

### Vegetable and Other Oils

|                          |      |      |   |       |
|--------------------------|------|------|---|-------|
| China wood oil           | lb.  | 26   | — | 29    |
| Cottonseed oil, crude    | lb.  | 20   | — | 22    |
| Linseed oil, raw, cars   | gal. | 1 64 | — | 1 66  |
| Peanut oil, crude        | gal. | 1 36 | — | 1 364 |
| Rosin, oil, fist run     | gal. | 60   | — | —     |
| Rosin oil, fourth run    | gal. | 78   | — | —     |
| Soya bean oil, Manchuria | lb.  | 18   | — | —     |
| Turpentine, spirits      | lb.  | 71   | — | —     |

### Miscellaneous Materials

|                                     |         |       |   |       |
|-------------------------------------|---------|-------|---|-------|
| Barytes, floated, white, foreign    | ton     | 38 00 | — | 42 00 |
| Barytes, floated, white, domestic   | ton     | 32 00 | — | 36 00 |
| Bauxite, white, pure                | lb.     | 42    | — | 43    |
| Caslin                              | lb.     | 14    | — | 28    |
| Chalk, light, precipitated, English | ton     | 17 50 | — | 36 00 |
| China clay, imported, lump          | ton     | 12 50 | — | 20 00 |
| China clay, domestic, lump          | ton     | 8 00  | — | 12 00 |
| Feldspar                            | ton     | 30 00 | — | —     |
| Fluorspar, gravel, f. o. b. mines   | 100 lb. | 1 50  | — | 2 00  |
| Fuller's earth, powdered            | lb.     | 10    | — | 25    |
| Graphite, flake                     | lb.     | 75    | — | 80    |
| Okzerite, crude                     | lb.     | 85    | — | 90    |
| Okzerite, American, refined, white  | lb.     | 85    | — | 111   |
| Red lead, dry, carloads             | bbl.    | 11 00 | — | 12 50 |
| Rosin, 280 lb.                      | ton     | 10 00 | — | 12 50 |
| Souapstone                          | ton     | 15 00 | — | 35 00 |
| Talc, American, white               | lb.     | 093   | — | —     |
| White lead, dry                     | ton     | —     | — | —     |

### Refractories, Etc.

(F. O. B. Works)

|                                  |             |        |   |        |
|----------------------------------|-------------|--------|---|--------|
| Chrome brick                     | net ton     | 175 00 | — | —      |
| Chrome cement                    | net ton     | 75 00  | — | —      |
| Clay brick, 1st quality fireclay | per 1000 50 | —      | — | 55 00  |
| Clay brick, second quality       | per 1000 35 | —      | — | 40 00  |
| Magnesite, raw                   | ton         | 50 00  | — | 65 00  |
| Magnesite, calcined, powdered    | net ton     | 50 00  | — | 60 00  |
| Magnesite, dross burned          | net ton     | 110 00 | — | 125 00 |
| Magnesia brick, 9x4x2 1/2        | per 1000 50 | —      | — | 60 00  |
| Silica brick                     | per 1000 50 | —      | — | 60 00  |

### Ferroalloys

|                                                      |     |        |   |        |
|------------------------------------------------------|-----|--------|---|--------|
| Ferrocobaltititanium, 15-18 per cent, carloads       | ton | —      | — | —      |
| F. o. b. Niagara Falls, N. Y.                        | lb. | 15 00  | — | 20 00  |
| Ferrocromium                                         | ton | 250 00 | — | —      |
| Ferromanganese, per lb. of Cr                        | ton | 325 00 | — | —      |
| Ferromanganese, English                              | ton | 5 00   | — | —      |
| Ferromolybdenum, per lb. of Mo                       | ton | 180 00 | — | 190 00 |
| Ferrosilicon, 75 per cent, f. o. b. N. Y.            | ton | 160 00 | — | 170 00 |
| Ferrosilicon, 50 per cent, powdered, del. Pittsburgh | lb. | 2 35   | — | 2 40   |
| Ferrotungsten, 75-85 per cent, f. o. b. Pittsburgh   | lb. | 7 50   | — | —      |
| Ferrovandium, f. o. b. works, per lb. of U           | lb. | —      | — | —      |
| Ferrovandium, f. a. b. works                         | lb. | —      | — | —      |

### Ores and Semi-finished Products

|                                                         |      |       |         |        |
|---------------------------------------------------------|------|-------|---------|--------|
| Antimony ore, per unit                                  | ton  | 1 50  | Nominal | 55     |
| Chrome ore, 45 per cent minimum, f. o. b. Cal. per unit | ton  | 1 20  | —       | —      |
| Chrome ore, 45 per cent and over, New York, per unit    | ton  | 1 50  | —       | —      |
| Manganese ore, 48 per cent and over, per unit           | ton  | 80 00 | —       | 100 00 |
| Manganese ore, chemical                                 | lb.  | 24 00 | —       | —      |
| Molybdenite, per lb. of MoS <sub>2</sub>                | ton  | 24 00 | —       | —      |
| Tungsten, Scheelite, per unit of WO <sub>3</sub>        | ton  | 3 25  | —       | 3 60   |
| Tungsten, Wolframite, per unit of WO <sub>3</sub>       | lb.  | 10 50 | —       | —      |
| Uranium oxide, 96%                                      | unit | 17    | —       | 17     |
| Vanadium pentoxide, 99%                                 | unit | 28    | —       | 303    |
| Pyrites, foreign                                        | unit | —     | —       | —      |
| Pyrites, domestic                                       | unit | —     | —       | —      |

# INDUSTRIAL

## Financial, Construction and Manufacturers' News

### Construction and Operation

#### Arkansas

**FORT SMITH.**—The Arkansas Mining & Mercantile Co., Boone and Marion Counties, will build a 200-ton concentration plant requiring drills, sludge and slime tables, engines, pits, boilers, compressors, ore crushers, track cars, belts and mill hardware. Estimated cost, \$60,000. F. A. Handlen, superintendent.

#### Connecticut

**COSCOB.**—The Mianus Manufacturing Co., 615 Fourth Ave., New York City, will build a 4-story, 42 x 145 ft. reinforced concrete dyehouse here. Estimated cost, \$40,000. Lockwood Greene Co., 101 Park Ave., New York City, engineers.

**NEW BRITAIN.**—The Traut & Hine Manufacturing Co., 510 Stanley St., has awarded the contract for the construction of a 1 and 3-story, 43 x 83 and 44 x 70 ft. concrete and brick addition to its factory for the manufacture of metal novelties, to W. H. Allen, New Britain. Estimated cost, \$35,000.

**TORRINGTON.**—The Fitzgerald Manufacturing Co. will build a 2-story, 50 x 300 ft. concrete and brick factory for the manufacture of brass goods on Railroad Ave. Estimated cost, \$60,000. E. H. Waterbury, Torrington, architect.

#### Georgia

**BRUNSWICK.**—The Ordnance Division, War Department, Washington, D. C., has awarded the contract for the construction of a picnic acid plant, here, to Butterworth-Judson Co., 51 Broadway, New York City. Estimated cost, \$7,000,000.

#### Indiana

**KOKOMO.**—The Kokomo Steel & Wire Co. will build a 1-story, 100 x 800 ft. reinforced concrete and brick factory. Estimated cost, \$150,000.

#### Kansas

**BAXTER SPRINGS.**—The Great Western Mining Co. will build a 500-ton concentration plant requiring lumber, engine, boilers, sludge tables, belts, crushers, hardware and scales. Estimated cost, \$75,000. O. F. Renner, superintendent.

**BAXTER SPRINGS.**—C. M. Mitchell will build a 200-ton concentration plant at his mine here and install mill hardware, lumber, sludge and slime tables, engine, boiler, crusher, air compressor and belts. Estimated cost, \$45,000. Buck Shelton, Baxter Springs, superintendent.

**BAXTER SPRINGS.**—C. E. Phillips will build a 150-ton concentration plant. Estimated cost, \$60,000. The company is in the market for sludge and slime tables, mill hardware, ore cars, lumber, drills, engines, boilers, belts. John Phillips, superintendent.

**GALENA.**—O. C. Hamilton, Connor Hotel, Joplin, Mo., will build a 200-ton concentration plant at his mine here and is in the market for ore crushers, ore cars, lumber, mill hardware, sludge and slime tables, air compressors, pipes and belts. Estimated cost, \$65,000.

**GALENA.**—The Lucky Jim Mining Co. will build a 200-ton concentration plant and install machinery, including sludge and slime tables, crushers, lumber mill hardware, scales, belts, air compressors and drills. Estimated cost, \$25,000. O. C. Hamilton, Galena, superintendent.

**GALENA.**—The Stag Mining Co. will build a 200-ton concentration plant and install machinery, including sludge and slime tables, ore crushers, lumber, drills and compressors. Estimated cost, \$60,000. F. L. Cook, superintendent.

**GALENA.**—The Stag Mining Co. will remodel its 150-ton mill to a 250-ton mill. Estimated cost, \$25,000. The company is in the market for lumber, mill hardware, belts, crushers, air compressors, ore bins, cars, track and drill. R. S. Harris, superintendent.

**TRECE.**—The Phoenix Lead & Zinc Co., Phoenix, will remodel its 200-ton mill and install belts, rollers, track, hardware and ore cars. Estimated cost, \$25,000.

#### Kentucky

**LOCKLAND.**—J. B. Speed & Co., Speed Building, Louisville, will build a potash plant. Estimated cost, \$100,000.

**LOUISVILLE.**—The Magic Keller Soap Works, 2745 Stecker St., has awarded the contract for the construction of a factory to the National Concrete Construction Co., engineers, Board of Trade Building.

#### Louisiana

**ALEXANDRIA.**—The Wm. Polk Co., 1209 Third St., will build a plant for manufacturing soap stocks, etc. Wm. Polk, care company, interested.

#### Maryland

**BALTIMORE.**—The American Can Co., Maryland Trust Building, will build a 4-story, 36 x 105 x 176 ft. reinforced concrete brick and steel factory on Boston and Hudson Sts., Canton. Estimated cost, \$180,000. N. M. Loney, 120 Broadway, New York City, architect.

**BALTIMORE.**—The Baltimore Tube Co., Wicomico and Ostend Sts., has purchased a site at Wicomico and Bayard Sts., and will build an addition to its plant here.

**BALTIMORE.**—Bartlett-Hayward Co., Scott and McHenry Sts., has awarded the contract for the construction of a 1-story, 479.5 x 618 ft. frame munition factory to Morrow Bros., Fidelity Building. Estimated cost, \$19,000.

**BALTIMORE.**—The Bureau of Yards & Docks, Navy Department, Washington, D. C., will build additional buildings at Marine Hospital, Remington Ave. and 31st St., including laboratories. Dr. C. W. Vogel, in charge.

**BALTIMORE.**—Elliott Machine Corporation, Bush and Severn Sts., will build a 1-story, 50 x 205 ft. reinforced concrete tool machine shop at Bayard and Wicomico Sts. Estimated cost, \$75,000.

**INDIAN HEAD.**—Bureau of Yards & Docks, Navy Department, Washington, D. C., will build 11 buildings as an extension to its powder factory. Estimated cost, \$338,500.

#### Michigan

**BATTLE CREEK.**—The Rich Steel Products Co. has awarded the contract for the construction of a 1-story, 49 x 112 ft. warehouse and a 49 x 256 ft. shop, mill construction, to C. Rasmussen, 254 West Randolph St., Chicago, Illinois.

#### Missouri

**DUENWIG.**—Frank Starkweather will remodel the 150-ton concentration plant recently destroyed by fire. Estimated cost, \$45,000. The company is in the market for sludge and slime tables, lumber, mill hardware, drills, rollers, engines, track and ore cars. P. Starkweather, superintendent.

**DUENWIG.**—The Vacation Mining Co. will build a 200-ton concentration plant. Estimated cost, \$65,000. The company is in the market for sludge and slime tables, mill hardware, ore cars, track engine, boilers, air compressors, belts, drills and crushers. Bud Craig, Joplin, superintendent.

**KANSAS CITY.**—C. R. Cook, Palm Co., 2107 Broadway, will rebuild its plant recently destroyed by fire entailing a loss of \$40,000.

**ORONOGO.**—The Connecticut Zinc Corporation, Joplin, will build an 1800-ton concentration plant here and install machinery, including sludge and slime tables, air compressors, belts, ore cars, crushers, scales, drills, engines. Estimated cost, \$200,000. Sidney Wilkens, Independent Bldg., Joplin, superintendent.

**WACO.**—The George Ball Mining Co. will build a 150-ton concentration plant. Estimated cost, \$60,000. The company is in the market for sludge and slime tables, crushers, jigs, mill hardware, belts, mill rollers, air compressors and conveyors. G. Ball, Webb City, superintendent.

#### New Jersey

**JERSEY CITY.**—The Air-Reduction Co., 177 Pacific Ave., has awarded the contract for the construction of a 4-story, 40 x 110 ft. reinforced concrete addition to its plant, to James Mitchell, 76 Montgomery St. Estimated cost, \$40,000.

**NEWARK.**—The Essex Foundry Co., Murray St., will build a 1-story, 75 x 180 ft. brick and steel factory on Elm St. Estimated cost, \$25,000.

#### New York

**BROOKLYN.**—The Kollmorgen Optical Co., 35 Steuben St., has awarded the contract for the construction of a 19 x 38 ft. concrete addition to its factory at Steuben St. north of Park Ave., to Metropolitan Corning & Sheet Metal Works, Flushing, and Metropolitan Aves. Estimated cost, \$5,000.

**BROOKLYN.**—The Improved Appliances Co., 455 Kent Ave., has awarded the contract for the construction of a 4-story, 60 x 92 ft. reinforced concrete and brick addition to its factory to Rufus H. Brown, 350 Fulton St. Estimated cost, \$15,000. Noted June 15.

**NIAGARA FALLS.**—The United States Light & Heat Corporation has awarded the contract for the construction of a 19 story, 150 x 300 ft. factory for the manufacture of lighting equipment and storage batteries, to Lauer & Mack, 1834 Pierce Ave. Estimated cost, \$35,000.

**PEARL RIVER.**—The Lederle Antitoxin Laboratory has awarded the contract for the construction of 2-story, 36 x 54 ft. brick veterinary laboratory to Ferber Construction Co., 16 Union Co. Rd., Hackensack, N. J. Estimated cost, \$25,000.

**SYRACUSE.**—The Brown-Lipe-Chapins Co., 110 Seneca St., will build a 2-story, 60 x 120 ft. concrete and brick factory for the manufacture of electrical fittings. Estimated cost, \$20,000. Taylor & Bouta, Gurvey Building, architects.

**SYRACUSE (Split Rock).**—The Sement-Solvay Co., River Road and Tonawanda St., Rochester, will rebuild its plant consisting of three T. N. T. plants, one nitric acid plant, one office building, one laboratory and one boiler house, at Milton Ave., Split Rock, which was recently destroyed by fire.

#### Ohio

**AKRON.**—City plans to build a modified Imhoff sewage disposal plant for Summit County Inland and Adams Sts. Estimated cost, \$18,000. M. P. Lauer, 707 Peoples Saving and Trust Building, engineer.

**CINCINNATI.**—The Lodge & Shipley Machine Co., 3055 Colerain Ave., will build a 1-story, 90 x 540 ft. brick and steel building for the manufacture of lathes. Estimated cost, \$100,000. Zettl & Rapp, Johnston Building, architects.

**CINCINNATI.**—John H. McGowan Co., 52 Central Ave., will build a 2-story, 87 x 87 ft. concrete and brick factory for the manufacture of pumping and hydraulic machinery. Thielt & Lee, Fourth National Bank, architects.

**CLEVELAND.**—The International Steel Tie Co., 16702 Waterloo Rd., will build a 1-story, 50 x 220 ft. steel factory. Estimated cost, \$30,000.

**CLEVELAND.**—The New York Central Railway, St. Clair and West 3d Sts., will build a 1-story, 97 x 163 ft. reinforced concrete, brick and steel locomotive repair shop at 564 East 152d St. Estimated cost, \$150,000.

**CLEVELAND.**—K. V. Painter, 3240 Fairmount Blvd., has awarded the contract for the construction of a 2-story, 108 x 132 ft. reinforced concrete and mill construction factory and salesroom for the manufacture of automobiles, to A. J. Kilbourne Co., 505 Sweetland Building. Estimated cost, \$50,000.

**CLEVELAND.**—The Steel Products Co., 2196 Clarkwood Ave., has awarded the contract for the construction of a 1-story, 9 x 100 ft. concrete and brick addition to its factory at East 65th St., to S. W. Emerson, 1900 Euclid Building. Estimated cost, \$14,000.

**CLEVELAND.**—The Western Machine Products Co., 7209 St. Clair St., has awarded the contract for the construction of a 2-story, 105 x 122 x 126 ft. concrete, brick and steel addition to its machine shop to Christian-Schwarzenberg & Gaede Co., 900 Euclid Building. Estimated cost, \$25,000.

**EUCLID.**—The Bishop-Babcock-Bocker Co., 1803 East 40th St., will build a group of factory buildings on a 26-acre site on Bliss Road for the manufacture of tacks, nails and bras.



**MARIETTA.**—The United States Government will build machine shops here for repairing Ohio River dams in Wheeling District. Address Col. H. W. Stickie, Wheeling, West Virginia.

**SPRINGFIELD.**—The Eagle Engineering Co., West Main St. and Bell Ave., will build a 1-story, 50 x 160 ft. reinforced concrete, brick and steel factory. Estimated cost, \$15,000.

**STRUTHERS.**—The Struther Furnace Co. has awarded the contract for the construction of a river intake plant to Baker, Dunbar & Allen, Union Ave., Pittsburgh, Pa. Estimated cost, \$102,000.

## Oklahoma

**BARTLESVILLE.**—The United States Government, Bureau of Mines, will build a 1-story, 40 x 100 ft. laboratory here.

**COMMERCE.**—The Safeguard Mining Co. will build a 200-ton concentration plant requiring lumber, mill hardware, boilers, engine, crushers, sludge and slime tables. Estimated cost, \$70,000.

**DOUZHAT.**—The Maurice Mining Co. will build a 300-ton concentration plant. Estimated cost, \$75,000. The company is in the market for a derrick, sludge and slime tables, lumber, mill hardware, crushers, boilers, engine, conveyors and compressors.

**GRANDY.**—The Grandy Consolidated Mines Co., Miami, will build a 300-ton concentration plant and install sludge tables, motors, mill lumber, mill hardware, air compressors, ore track bins, slime tables, boilers and engines. Estimated cost, \$13,000. W. G. Wilkerson, superintendent.

**LINCOLNVILLE.**—The Miami Sunrise Mining Co., Miami, will build a 200-ton concentration plant at its mine near here, requiring sludge tables, engines, boilers, drills, lumber, mill hardware and air compressors. Estimated cost, \$60,000.

**LINCOLNVILLE.**—The Nemo Mining Co. will remodel its 200-ton concentration plant and install machinery, including sludge tables, belts, crushers and drills. Estimated cost, \$10,000.

**MIAMI.**—The Picher-Oklahoma Mining Co. will build an 800-ton concentration plant requiring sludge and slime tables, mill hardware, crushers, air compressors, belts and ore cars. Estimated cost, \$75,000. A. J. Harrington, superintendent.

**MIAMI.**—The United Development Co., Oklahoma City, will build a 250-ton concentration plant and install machinery, including mill hardware, lumber, roofing, engine, boilers, crushers, belts and air compressors. Estimated cost, \$75,000. V. E. Conkle, superintendent.

**OKLAHOMA CITY.**—The Indian Chief Mining Co. will build a 300-ton concentration plant. B. C. Clark, Purcell, president.

**PEORIA.**—The Dallas Miami Mining Co. will build a 250-ton concentration plant. Estimated cost, \$65,000. The company is in the market for mill hardware, crushers, motors, belts, track, ore cars, mill hardware, crushers, rollers, engine and compressors. A. J. Herrington, superintendent.

**PEORIA.**—The King Bee Mining Co. will build a 200-ton concentration plant and install machinery, including sludge and slime tables, drills, compressors, belts, mill hardware, ore cars and lumber. Estimated cost, \$60,000.

**PEORIA.**—The L. C. H. Corporation has awarded the contract for the construction of a 200-ton concentration plant to Hess Construction Co., 1831 Moffet Ave., Joplin, Mo. Estimated cost, \$45,000. The company is in the market for mill hardware, crushers, mill hardware, lumber, crushers, engine, boilers, belts and air compressors.

**PICHER.**—The Ottawa Metals Co. will build a 175-ton concentration plant requiring mill hardware, lumber, engine, rollers, slugs, rollers, crushers, air compressors, belts, ore cars and conveyors. Estimated cost, \$45,000.

**PICHER.**—The Picher Lead Co. will build a 200-ton concentration plant. Estimated cost, \$60,000. The company will install sludge and slime tables, mill lumber and hardware, ore cars, track, belts, engine, boilers, rollers, air compressors and pipes. C. Potter, superintendent.

**QUAPAW.**—The Quapaw Jack Lead & Zinc Co. will build a 200-ton concentration plant and install machinery, including drills, air compressors, sludge and slime tables, mill hardware, crushers, rollers, conveyors. Estimated cost, \$65,000. B. W. Ward, superintendent.

**QUAPAW.**—The Quapaw Mining Co. will build a 250-ton concentration plant requiring mill hardware, sludge and slime tables, drills, belts, rope and air compressors. Estimated cost, \$72,000.

**QUAPAW.**—The Ruth Strike Mining Co. will build a 300-ton concentration plant and install machinery, including crusher, sizer, compressor, gas engine, sludge and slime tables, lumber, mill hardware, belts, track and ore car. Estimated cost, \$30,000. A. O. Baker, Shawnee, superintendent.

**SPAVINAW.**—The Red Granite Copper and Water Power Co., Strand, will build a concentration plant. Estimated cost, \$25,000. The company is in the market for crushers, engine, rollers, ore cars, bins, lumber, track screens, belts and mill hardware. W. E. Hudson, Connor Hotel, Joplin, Mo., superintendent.

**ST. LOUIS.**—The Miami Wonder Mining Co., Miami, will build a 200-ton concentration plant at its mine near St. Louis and install crushers, mill machinery, sludge and slime tables, belts, engine, rollers, drills, boilers, air compressors. Estimated cost, \$60,000. A. V. Ellis, superintendent.

## Pennsylvania

**PHILADELPHIA.**—The Niles-Bement-Pond Co., 21st and Callowhill Sts., has awarded the contract for the construction of a 1-story, 65 x 115 ft. addition to its foundry on Ruffner and Donath Sts., to Austin Co., Bulletin Bldg. Estimated cost, \$20,000.

**READING.**—The Philadelphia & Reading Railway has awarded the contract for the construction of a 1-story, 100 x 150 ft. brick and steel machine shop to E. Warfel, Lancaster. Estimated cost, \$40,000.

## Rhode Island

**PAWTUCKET.**—The Potter & Johnston Co., Newport Ave., has awarded the contract for the construction of a 1-story, 171 x 486 ft. mill construction plant for the manufacture of shells and glass. The Industrial Trust Bldg., Providence. Estimated cost, \$150,000.

## Texas

**BROWNWOOD.**—The Brownwood Glass Manufacturing Co. will build a glass factory. Estimated cost, \$100,000. H. Wagner, Tulsa, Okla., president.

**CISCO.**—The Liberty Refining Co., C. A. Gray Building, will build an oil refinery here. G. J. Ames, president.

## Washington

**SEATTLE.**—The Alaskan-Copper Works, 1041 Railroad Ave., will build a 1-story, 50 x 87 ft. machine shop at 3600 East Marginal Way. Estimated cost, \$6,000. Frank Cruise, Washington Block, architect.

**SEATTLE.**—The Seattle Pipe & Galvanizing Co., 1st Ave. South and Stacy St., has awarded the contract for the construction of a 1-story, 52 x 150 ft. plant for galvanizing ship supplies and heavy hardware to Geo. Eckman, Pacific Block. Estimated cost, \$40,000.

**SEATTLE.**—P. J. Appleton, 1111 1st Ave., has awarded the contract for the construction of a 2-story, 43 x 200 ft. foundry machine shop at 1410 Dearborn St. to W. Husekamp, 1255 John St. Estimated cost, \$5,000.

## Quebec

**TEMISKAMING.**—The Kipawa Fibre Co., in which the Klondan Pulp & Paper Co., 355 Beaver Hall St., Montreal, is interested, will build a pulp and paper plant.

## Wisconsin

**MILWAUKEE.**—The Standard Steel Corporation, Hopkins Rd. and Lake St., will build a 2-story, 40 x 200 ft. factory and a 40 x 140 ft. foundry. F. D. Chase, 122 St. Michigan Ave., Chicago, Ill., architect. E. J. De Guenther, 908 Majestic Building, interested.

**THE SCIENTIFIC UTILITIES CO., INC.,** 84 East 11th Street, New York City, has recently been incorporated by the trustees of the company with the American Scientific Instrument Co. The new company is a modern glass blowing shop and is prepared to furnish the trade with special apparatus.

**THE TRAYLOR ENGINEERING AND MANUFACTURING CO. of Allentown, Pa.,** announce the following election of officers: Mr. Samuel W. Traylor, chairman of the board, Mr. William J. Roberts, president and Mr. H. Battersby, vice-president and treasurer.

**THE MULTI METAL CO., INC.,** is the new name for the Multi Metal Separating Screen Co., which took effect July 1, 1918.

**THE ABRONOME COMPANY OF PITTSBURGH,** (formerly the American Portland Cement Metal Company) announces the removal of its

Chicago office on July 1, 1918, to the Railway Exchange Building, New York. Mr. T. O'Neill will continue in charge as district manager.

**THE INDUSTRIAL ELECTRIC FURNACE COMPANY, Chicago,** makers of the Snyder Electric Furnace, are installing a three-ton furnace in the new building of the Atlantic Foundry Company, Akron, Ohio. It is a three-phase furnace built for acid operation on general steel casting work, and was purchased as a by-product of scientific research. The company has a general manager, president and general manager, and John Steckel, treasurer and purchasing agent, of the Atlantic Foundry Co.

**THE PYROLYTIC INSTRUMENT CO.,** 636 East State Street, Trenton, N. J., announce that their Northrup-Ajax high-frequency induction furnace developed by Dr. E. F. Northrup for the Ajax Metal Company of Philadelphia is now available for scientific and experimental purposes in five sizes—6 kw., 8 kw., 12 kw., 16 kw. and 20 kw. This furnace operates upon a radically new principle and is said to give results not obtainable by any other type of electric furnace heretofore invented. It is fully described in a new twenty page illustrated circular just issued by the Pyrolytic Company. To those interested in acquiring one of these furnaces this circular will be sent upon request.

**PITTSBURGH TESTING LABORATORY** announces the removal, July 1st, 1918, from its temporary quarters in the E. T. O'Neill Law Building to its new office and laboratory buildings at 612-620 Grant Street, Pittsburgh, Pa. Our laboratories will be larger and better equipped than those in our old quarters, the P. T. L. Building, at Seventh and Bedford Avenues, which we turned over to the Government on April 1st, 1918.

**THE KOPPERS COMPANY, Pittsburgh, Pa.,** has been awarded a contract by the Jones and Laughlin Steel Company for the construction of a by-product coke plant of 300 ovens, which will have a washing capacity of approximately 2,000,000 tons per year, which will replace beehive coking capacity of that amount. This plant will be equipped for recovering ammonia in the form of ammonium sulphate of tar and of benzol and toluol as pure products. The ammonium sulphate and pure toluol will be sold to the Government for war purposes. The steel company plans to use the gas in its steel plant operations.

A NEW 6-TON ACID OPEN-HEARTH FURNACE has recently been completed by the Atlantic Steel Castings Co., Chester, Pa., and is being installed at the light casting of nickel steel. The company is engaged on Government war work.

**THE ZENITH FURNACE CO., Duluth, Minn.,** have retained Freyn, Brassett & Co., Peoria, Ill., Chicago, for the remodeling of their furnace, the installation of a Brassett gas-washing and drying unit, the erection of a new hot-blast stove and other plant improvements.

**FOUR NEW GAS PRODUCERS,** built by the Morgan Construction Co., Worcester, Mass., are being installed at the Youngstown Sheet & Tube Company's plant at Youngstown, Ohio, to replace the old producers.

**THE HANCOCK ROCK IRON CO.,** Hanging Rock, Ohio, have awarded a contract to the A. G. McKee Co., Cleveland, for improvements to the Hamilton plant which will include a skip bridge, conveying distributor, scale cars and a one 50-ton transfer car.

**THE CANADIAN FERRO ALLOYS, LTD.,** Shawinigan Falls, Que., Canada, is building a plant for the production of ferro alloys. They expect to ship in addition to their regular products, 17 tons of 50 per cent ferrosilicon daily.

## Manufacturers' Catalogs

**THE CUTLER-HAMMER MANUFACTURING CO., Milwaukee, Wisconsin:** A pamphlet on battery charging equipment for trucks and vehicles and industrial trucks. Another pamphlet is issued by the above company on C-H 9116 starting switch for squirrel cage motors.

**THE CLARAGE FAN COMPANY, Kalamazoo, Mich.:** Catalog No. 22 on style "C" pressure blowers giving a general description, general data and capacity tables.

**THE P. H. & F. M. ROOTS COMPANY, Connersville, Ind.:** Catalog 63 on the Roots Rotary Gas Exhaustors, for promoting feature is the publication of tables of engineering data, designed to make the catalog valuable as a reference book to any one interested in the manufacture or use of gas. This catalog describes and illustrates rotary gas exhaustors for foul gas pumping service, corrosive gas handling with high-pressure booster service and special linings.

# CHEMICAL & METALLURGICAL ENGINEERING

A consolidation of ELECTROCHEMICAL & METALLURGICAL INDUSTRY and IRON & STEEL MAGAZINE

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## September's Conventions

THE month of September promises to be a busy one for those who have occasion to attend professional gatherings. The American Institute of Mining Engineers holds its one hundred and seventeenth meeting in Colorado through the first week of the month, visiting Denver, Colorado Springs, Cripple Creek and Pueblo. The American Chemical Society will convene in Cleveland, Ohio, the following week, holding meetings on the tenth to the thirteenth inclusive. Apparently no meetings have been scheduled for the third week in the month but in the following week the Fourth National Exposition of Chemical Industries will be held at Grand Central Palace, New York. The American Electrochemical Society closes the fall schedule with meetings at Princeton, N. J., from Sept. 30 to Oct. 2.

This is a rather rapid-fire program for those whose interests in chemistry and metallurgy make attendance on the conventions of these societies desirable if not essential. In spite of the earlier agitation against wartime conventions there seems to be no abatement of interest, which may be attributed to the fact that not only are the conventions profitable in themselves, but they afford a very desirable form of relief from the strenuous personal schedules which most technical men are obliged to lay out for themselves.

It has been our own observation that very definite and tangible results of benefit to the war program of the country come from these professional gatherings. There is much information of a technical nature which can not be offered for publication, but which men will communicate to each other freely if the opportunity of a personal meeting is afforded. The convention supplies the common meeting ground with the right atmosphere for professional intercourse. It will be our pleasant duty to report all these gatherings fully for the benefit of those who cannot attend.

## Platinum, Rice and War Weddings

WE NEED an enlightened public conscience on the subject of platinum. We have one on the subject of food and it worked wonders in enabling us to conserve our supplies, feed ourselves and our Allies, and in general get the matter so well in hand that the Food Administrator could announce recently that there is no danger of a crisis. If the general public had as keen a sense of patriotism regarding platinum as it has on the subject of food, we would hear less of a platinum shortage and our supply of the metal would be plainly useful instead of doubtfully ornamental.

What the lack of appreciation of the platinum situation means among good citizens of a high degree of



intelligence is well illustrated by a recent war wedding to which we were a witness. The groom was an army officer, shortly to sail overseas in the performance of his patriotic duty, there to make the supreme sacrifice if necessary, and placing reliance for his safety and support on the steady production of munitions at home. The bride was a fair daughter of a family of the better class, but more familiar with platinum as an ornament than a catalyst. Because platinum has been in vogue for wedding and engagement rings, and wishing to present his bride with the best the market afforded, the groom had selected jewelry of the white metal, wholly unmindful of the anomaly of a soldier sacrificing in ornamentation that which is an essential to the production of the munitions on which he must rely for his personal safety. And after the ceremony was over and the couple left the scene, the assembled company patriotically refrained from spoiling fifteen cents worth of rice wherewith to perpetuate an age-old tradition on such occasions. All of which suggests the need of a conscience on platinum as first mentioned. Is it not time that chemists and metallurgists spread the gospel of platinum for munitions and publicly frown upon slacker uses of platinum? The people are intelligent and patriotic at heart, but uninformed and therefore careless in their actions. It is wholly a question of education, for which technologists are to be held responsible.

#### Test Iron Ores and Fluxes for Potash

DOMESTIC production of potash in 1917, according to the U. S. Geological Survey, amounted to 32,366 tons of available  $K_2O$ . Natural brines yielded 20,652 tons and easily proved to be the premier source. Kelp was second with 3572 tons; and molasses, alunite and cement-kiln dust followed with 2846, 2402 and 1621 tons respectively. Thereafter no item in the list attains the dignity of a production requiring more than three figures, and blast-furnace dust ends the list with a production of but 185 tons  $K_2O$ , being appreciably less important than wood ashes, the residue from evaporation of Steffens water from sugar refineries or similar residues from wool washing and other industrial wastes.

Judged from these figures alone, blast-furnace dust would not appear to be much of a factor in the prospective production of potash in this country. And yet there are certain technical and economic features about the recovery of potash from this source that lead us to urge chemists and metallurgists everywhere to be diligent in analyzing all iron ores and fluxes for this important mineral.

Our future independence in potash supply is likely to rest largely in that item of our production which is most nearly a cheap by-product. Careful and continued geological exploration for several years has afforded no hope of discovering deposits comparable to those of Europe, or indeed any that seem important. By-products, therefore, assume added value and it behooves us to take careful stock of this asset. The by-product which will be most valuable will be one that accompanies a material for which there is an unlimited demand, so that no glut of the principal market can reduce the output of the minor product.

Iron ores and fluxes fulfill in a peculiar degree all the

conditions for an almost ideal source of potash as a by-product, and make a careful survey desirable if not imperative. These materials are used in large quantities, so that if they contain what would otherwise be a negligible percentage of potash they will nevertheless yield an appreciable total in the aggregate. The potash content can be recovered in the process of cleaning the furnace gases, which is in itself a desirable operation even if no valuable by-product were sought. It is quite evident, then, that if our large iron deposits should be found to be potash-bearing, we have a source of potash that is practically without expense. Transportation and treatment charges would be absorbed by the principal product, and the by-product would be clean profit. On such a basis it would not be difficult to compete with German potash at any price. We deem the subject worthy of the most careful investigation and shall be glad to open our columns to those who may undertake researches in this line or who may have knowledge of the extent to which potash exists in our iron ores, dolomite limestones and coke.

#### Science and the German Language

THERE is a great deal of hysteria in the daily press about dropping the study of the German language from schools and even colleges. We see no good in the plan. It reminds us of the man who bit off his nose to spite his face. Why interject non-essentials at a time like this? Of course we do not favor schools conducted in the German language, and we believe in making short shrift of German propaganda either now or at any other time—until the German people get over their present delirium and know enough to be ashamed of themselves.

Let us try to get a broad view of the situation. The Germans followed Kant in the belief that there is no relation between science and ethics. The Prussian drill in obedience to authority had its effects here as well as elsewhere and Kant, being a philosophical authority, became the final and binding word upon the German conscience. For generations the German people have been almost feeble-minded in their inhibitions against the voice of authority. "There can be no revolution in Germany," said Heine, "because revolution is *verboten*." But now the Germans have very effectively done as they were told; they have divorced science from ethics and—we see the results.

In times past, however, they had their periods of enlightenment, and in elucidation of this we shall repeat an example that we have mentioned before. It was sometime in the seventies that Professor Josiah Willard Gibbs of Yale University read a paper on the phase rule, before the Connecticut Academy of Sciences at New Haven. It is not of record that anybody understood what he was talking about. Then many years later, sometime in the nineties as we recall it, the elder Ostwald, being still in his right mind, set out to find all that he could about Willard Gibbs, whose infrequent contributions had aroused his lively interest. Looking over the published transactions of the Connecticut Academy, he discovered to his unutterable delight the very thing he had long been wishing for: the phase rule stated and worked out. He immediately trans-



lated it into German, giving full credit to the author and his source of information, and published it to the great illumination of the scientific world. It is fair to say that we Americans got the phrase rule from the German, although it appeared originally within less than 100 miles from New York, and it was written and delivered in English.

If we didn't know enough then to see a good thing when it was put before us, it stands to reason that we are capable of letting other good things slip by unobserved, even in this day of blind rage. And it is a bad thing for science in America or anywhere else to let additions to enlightenment pass by, whether they come from Germany or Zambesi or Timbuktu. Facts are facts and information is information. We must not misuse them, neither must we close our eyes to them. The German language is to-day the richest in chemical literature as it is also in certain other branches of science, and to prevent the study of it would be nothing more than giving way to hysterics. It would often involve waiting a year for partial and inadequate translations. The war is not won yet; everyone of us has a man's job ahead of him, and there is neither profit nor wisdom in browsing about in the silly-ass pasture.

### Flexibility of the Steel Industry

THE combination in the steel industry of all steel-making departments being operated as fully as possible with many finishing departments operating at only about 60 per cent of their capacity is one that would not have been believed possible a few years ago. Normally the sum total of the finishing capacity exceeds but slightly the total ingot-making capacity, and when there is full production of ingots there must necessarily be nearly full employment of finishing departments. For a time after the European war started, moreover, there was erection of open-hearth furnaces without attendant increases in finishing capacity, thus making the alignment between steel-making and steel-finishing capacity closer than ever.

Yet the condition to-day is that every works is striving to turn out a maximum tonnage of ingots while the rod, merchant and sheet mills are operating at only about 60 per cent of capacity, the production of steel pipe is light and the production of rails far below capacity. Ingots, blooms and billets are extremely scarce. The finished products that are most needed for war purposes are being produced in great volume while the products less needed for war purposes are being produced in small volume.

The steel industry is showing a flexibility that would not have been expected. Indeed, there were many predictions a year and more ago that our entrance into the war could not make steel of all descriptions scarce, for the war would require large tonnages of some finished forms and little tonnage of others, which perforce would be plentiful. Thus the steel industry has adapted itself in remarkable manner to the peculiar demands made upon it.

Several causes have contributed to make this alignment possible. The two chief factors are the heavy production of shell steel and the large increase in plate-

rolling capacity. Precise figures are not available, but a fair estimate is that half a million net tons of shell steel a month is being made. The records at Washington are made up in net tons, so that unit may as well be used. This shell steel involves the use of scarcely any finishing capacity. Next, there is an output of plates probably materially in excess of half a million tons a month, an increase of considerably more than 50 per cent over the output in 1916, when every effort was being made to swell the production of plates, which were easily the scarcest commodity in the steel market. The major portion of the new plate mill construction has been without increase of capacity of the attendant steel works and indeed some plate mills have been built without slabbing mill capacity, requiring slab ingots or blooming mill slabs.

A relatively minor factor from a tonnage standpoint, and yet an important one, is the heavy operation of the tin-plate mills. They have lately been producing at the rate of 160,000 net tons a month, against an output of 115,000 tons a month in 1916. This heavy operation tends to make crude steel scarce in general, and in particular it makes such a drain upon the sheet-bar supply that the sheet mills are but poorly provided. The proportion of the total steel supply passing into sheet bars is not much under normal, but the division of the sheet-bar supply is quite abnormal.

The structural mills are not operating at an abnormally heavy rate but are probably consuming their usual proportion of the total steel supply, and this leaves it that the operations of rod bar, rail, sheet, merchant and skelp mills are very far below capacity, probably averaging in the neighborhood of 60 per cent. It is understood that the rod mills are definitely limited to a 60 per cent operation.

The production of ingots in June was at the rate of about 43,500,000 gross tons a year, there having been an increase in the rate each month since the very low rate of last January. For a period of years before the war the output of finished rolled steel was almost precisely, year by year, 76 per cent of the weight of ingots reported. On account of the discard involved in shell steel production the percentage of rolled steel may have declined a trifle, but 75 per cent is a safe factor to use, and this would mean 3,000,000 net tons of finished rolled steel a month when ingots are being produced at 43,500,000 tons a year. With at least 1,160,000 tons involved in shell steel, plates and tin plates the operations of other finishing departments must be light.

There is a very interesting coincidence, that plates, structural shapes and tin plates are not carried in stock by mills, wholesalers or retailers to any extent. Merchant bars, pipe, wire products and sheets are normally carried in stock. At any one time there is a very considerable stock in the country. There is no scarcity of these materials from the standpoint of carrying on the war, but there is a possibility, with the continued restriction in output, that eventually a serious shortage will come to light. The steel industry has responded quickly and fully to the peculiar demands of war. The probabilities are that these demands will continue and may even increase, but should they slacken there is a reserve of demand for steel in replenishing the stocks throughout the country, now being depleted.

## Readers' Views and Comments

### Oil Shales, Albertite and Paper Shales

To the Editor of *Chemical & Metallurgical Engineering*

SIR:—In the interesting article published in your June 1 issue on "The Economic Position of Oil Shales" by Jac. C. Morrell and Gustav Egloff certain errors occur.

On page 603 appears a reference to "albertite, an oil shale from New Brunswick, Canada, known as paper shale." I desire to point out that albertite is not an oil shale nor has it ever before been so called or known as "paper shale." Albertite is solidified oil, found in a vertical vein that cuts through the many beds of shale found in the valley of the Frederick Brook and known as the Albert Mines.

Many years ago the albertite in the vein was mined. The mineral was said to have an analysis as follows: Volatile matter 54 per cent fixed carbon over 45 per cent, and ash only 0.17 per cent. On retorting it is claimed that the albertite yielded crude oil of from 100 imp. gallons to 130 imp. gallons per ton. The paper shales of which there are large masses exposed in the banks of the Frederick Brook yielded the following:

- A. 32 Imperial gallons oil and 38 lb. sulphate of ammonia.
- B. 34 Imperial gallons oil and 38 lb. sulphate of ammonia.
- C. 42 Imperial gallons oil and 38 lb. sulphate of ammonia.

Besides the large masses of paper shales, there are also exposed distinct beds of black and curly shale, which yield as follows:

1. 41 Imperial gallons oil and 39 lb. sulphate of ammonia.
2. 63 Imperial gallons oil and 52 lb. sulphate of ammonia.
3. 52 Imperial gallons oil and 73 lb. sulphate of ammonia.
4. 42 Imperial gallons oil and 52 lb. sulphate of ammonia.

All these analyses were made in the laboratory of the Department of Mines, Ottawa, and are more correct than those given in Table VI, where the results of samples from Albert Mines and from the Frederick Brook are given separately (in some cases probably duplication has occurred) whereas all belong to the same property, viz., Albert Mines. It will be noted that these results are markedly different from the results obtained from shales in Scotland, where the paper shales are not considered to be of economic importance, and where the shales that are low in oil content are usually high in the yield of sulphate of ammonia.

Nor is it correct to claim that the paper shale contains considerable quantities of fish remains; nor can the presence of the fish remains, as present in the Albert Mines shales, prove the origin of the hydrocarbons. It is true that in one exposure of one of the beds of the paper shales, which at this point are so badly crumpled that at first it would appear as if the whole formation has been tilted on end, there are

considerable of such remains. Their presence is, of course, interesting, but as "one swallow does not make a summer" so the presence of fish remains in the outcroppings of one bed of shale, of small thickness, would in my opinion if anything, tend to prove that the hydrocarbon contents of other beds of shale did not owe their origin to the remains of fish. Why should the remains be plentiful in this one thin bed and yet be entirely or almost entirely absent in the many other beds, all of which yield oil in considerable quantities.

So far as I am aware the shale from the bed that contains these remains has never been analyzed. Some day, as a matter of scientific interest, I hope that the shale of this bed will be analyzed and also of the beds above and below, in which no remains are found.

In the second article by the same authors in your issue for July 15 I call your attention to the comparative statement given on page 95, clause 6, of the general summary on the same page, and clause 12, page 96.

Apart from the fact that the statement as made is of no practical value, because averages so made can be manipulated, the comparison is unfair to Scotland and Canada.

The U. S. gallon runs 42 to the barrel. The gallon used in Scotland and Canada runs only 35. Since the average given for Scotland is (though not so stated) the Scotch average in Imperial gallons and since it is improbable that the authors would use the Imperial gallon for the results obtained by them from United States shales, it is evident that the returns for Scotland and Canada should be increased by one-fifth in order to compare fairly with U. S. returns. This would make the returns from Scotland 27.6 U. S. gallons and from Canada 41.9 U. S. gallons.

Clause 6 in the general summary requires correction for the same reason. Clause 12 suggests that the writers have small knowledge of the industrial end of the oil question. As California, Texas and Mexican crude oils are different from the crude oils of Pennsylvania, so are the oils retorted from the shales of one deposit different from those of another. Oils from one bed are different from oils of another and the oils from the same shales will vary with retorting in different retorts. I wish to say also that the laboratory retort heated by the Bunsen burner is not satisfactory for precise work, which should be undertaken in retorts in which the heat control can be better governed.

LOUIS SIMPSON.

Ottawa, Can.

### The Economic Position of Oil Shales

To the Editor of *Chemical & Metallurgical Engineering*

SIR:—The following addition should be made to our recent article on oil shales appearing in your issue for June 1, 1918, page 603:

To the section on the origin of petroleum should be added the highly interesting theory developed by Dr. Clifford Richardson\* that "the origin of petroleum is to

\**Jour. Ind. and Eng. Chem.* 8, 4, 1916; *Met. and Chem. Eng.* 16, 1917. (Jan. 1).

be attributed to the relation of surfaces and films of certain natural gases, either as a gas under pressure, at the levels where it exists, in a liquid state, to surfaces of solids, the oil 'sands' with which the former comes in contact." This theory seems to indicate that a highly catalytic and colloidal action takes place between the surfaces and films of certain natural gas to solid surfaces forming petroleum oil. The uniqueness of the theory has resulted from years of observation and experimental data along bituminous and natural gas lines, emanating from the Trinidad fields of which the latest gas samples show the constituents to be:

## FROM SURFACE OF ASPHALT DEPOSIT

|                                                                              | CH <sub>4</sub> | C <sub>2</sub> H <sub>6</sub> | CO   | N   | H <sub>2</sub> S |
|------------------------------------------------------------------------------|-----------------|-------------------------------|------|-----|------------------|
| Centre of Lake.....                                                          | 85.1            | 4.1                           | 9.8  | 0.0 | 0.0              |
| Where gas bubbles issue violently from centre of lake.....                   | 74.2            | 4.0                           | 20.0 | 0.0 | 0.8              |
| Where small bubbles issue gently from surface of water at centre of lake.... | 64.7            | 4.7                           | 26.3 | 0.0 | 2.7              |
| 1 Ibid.                                                                      |                 |                               |      |     | 1.6              |

It will be important to learn of Dr. Richardson's experimental verification of his theory, for with catalytic and colloidal phenomena playing their rôle in the origin of petroleum, the laboratory should speed nature's work and furnish us with bituminous material in measurable time from natural gas of certain composition. The results of Bardwell, Berryman, Brighton and Kuhre<sup>1</sup> have been brought into question and the following data corrections noted. Samples of the hydrocarbons under discussion (by Dr. Richardson) were reanalysed by T. B. Brighton and by the N. Y. Testing Laboratory with the following results:

| N.Y.T.L.                                 | Trinidad Per Cent | Bermud-z Per Cent | Talalyts Per Cent |
|------------------------------------------|-------------------|-------------------|-------------------|
| Bitumen soluble in CS <sub>2</sub> ..... | 56.9              | 92.5              | 94.7              |
| Mineral Matter.....                      | 35.6              | 5.1               | 4.8               |
| Fixed Carbon.....                        | 12.0              | 12.9              | 9.2               |
| T. B. Brighton                           |                   |                   |                   |
| Bitumen soluble in CS <sub>2</sub> ..... | 57.5              | 92.3              |                   |
| Mineral matter.....                      | 35.7              | 5.3               |                   |
| Fixed carbon.....                        |                   |                   |                   |
| N.Y.T.L.                                 | Gilsonite         | Wurzelite No. 1   | Wurzelite No. 2   |
| Bitumen soluble in CS <sub>2</sub> ..... |                   |                   |                   |
| Mineral Matter.....                      |                   |                   |                   |
| Fixed Carbon.....                        | 13.6              | 7.8               | 7.5               |

JAC C. MORRELL AND GUSTAV EGLOFF.

## Organic Reagents for Research Purposes

To the Editor of Chemical & Metallurgical Engineering

SIR:—In order to provide for the supply of organic reagents for research and industrial purposes the Eastman Kodak Company has determined to commence their preparation in its research laboratory.

This decision was arrived at as a result of the articles published by Dr. Roger Adams and of a recent letter by Professor Gortner in *Science* (June 14, 1918, p. 590), which drew our attention to the need for an adequate supply of these materials produced by a firm of standing.

In order to carry on the work a separate section of the laboratory has been established under the title of the "Department of Synthetic Chemistry," which will be under the immediate direction of Dr. H. T. Clarke, well known for his publications on organic chemistry.

In order to make available to research laboratories in this country the organic chemicals which they require, it is proposed that chemicals for research work shall be supplied at the lowest possible price. At first, no doubt,

this price will necessarily be higher than that charged by the German firms before the war, but it is hoped that eventually the profit made on chemicals supplied for commercial purposes may enable the rarer materials made in small quantities for research work to be sold at a price which will be within the reach of all who require them.

At first, of course, the laboratory will be able to supply only a limited number of substances, and these in small amounts, but the department will be expanded to meet the demand and with the assistance of other laboratories interested in organic chemistry, and of the firms who are producing dyes and intermediates, it is hoped that after a time an adequate supply of synthetic organic reagents can be made available.

It is possible that laboratories may have in stock unusual reagents which they are unlikely to require. If any laboratories possessing such reagents will write to us we shall be glad to make an offer for the materials, thus making them available on the market.

Our thanks are due to many of the chief chemists of the country who have encouraged us to commence this work and especially to Professor Roger Adams for the way in which he has received our proposals and has assisted us by placing at our disposal the information as to this work which he has accumulated.

Communications regarding reagents should be addressed to the Research Laboratory, Eastman Kodak Company, Rochester, N. Y.

C. E. K. MELES.

Rochester, N. Y.

## Conforming to the Prior Art in Flotation

To the Editor of Chemical & Metallurgical Engineering

SIR:—During the past fifteen months Mr. Parker C. Choate has made four communications to you, the last three dwelling particularly upon the equities involved in the Minerals Separation litigation.

It seems to me that Mr. Choate, as I read his communications, has a wrong impression as to the attitude assumed by those using oil in excess of Minerals Separation patent. He is apparently under the impression that the use of oil in excess of the patent is considered by them as "a new process." He says in his communication of May 1, 1917 (*Met. & Chem. Eng.* Vol. 16, page 469):

"They talk of a new process, yet perhaps there is no technical reason why more than 1 per cent of oil gives better results, but merely the commercial reason to avoid royalty payment to a capitalized patent interest that must be fought, right or wrong."

And again in his communication in the current issue, July 15, 1918 (*Chem. & Met. Eng.*, Vol. 19, page 60) he says:

"If it were shown by defendants that there was an advance in the art, or a new process discovered by the use of oil, in any way, in excess of a fraction of 1 per cent, then the ruling of the California Court would be understandable."

Mr. Choate appears to be under the impression that Minerals Separation holds the basic position, that they

<sup>1</sup>Ibid.<sup>2</sup>*Jour. Ind. and Eng. Chem.* 5, 973, 1913, and 6, 565, 1914.

<sup>3</sup>March 1st, 1917, "Research and Industry," Vol. 16, page 241.  
 May 1st, 1917, "Evolution of Patent Suit Decisions," Vol. 17, page 459.  
 Oct. 15th, 1917, "Invention & the Flotation Suits," Vol. 17, page 452.  
 July 15th, 1918, "The Recent Flotation Decision," Vol. 19, page 60.



are the prior art. The fact is that the oil in excess of a fraction of 1 per cent was used by defendants to conform to the prior art and was frankly so stated. No claim whatever was made to "a new process" and there was no such "talk" by the defendant.

The court in San Francisco found no such distinction between efficient and non-efficient oils, as Judge Bourquin apparently injected into the patent. Everson had claimed oils and fats and fatty acids very broadly, and patent 835,120, of Minerals Separation, was no less broad as to the character of oil, simply claiming novelty as to quantity of oil used and manner and time of agitation.

Mr. Choate is absolutely wrong when he states that the decision of the Delaware court was sustained by the Supreme Court.

The U. S. Circuit Court of Appeals, in Philadelphia, reads the Supreme Court decision very differently from Mr. Choate. In the opinion of these judges the Supreme Court found the process of the patent to consist of an agitation greater than that of the prior art, in combination with a "critical" proportion of oil, and producing a froth different from that theretofore produced, whereas Judge Bradford had found that reduction in the quantity of oil of the process, as compared with the quantity of the prior art, was so great, as to in itself constitute invention.

R. C. CANBY.

Wallingford, Conn.

## Metallurgy of Zinc

*To the Editor of Chemical and Metallurgical Engineering*

SIR:—Concerning the discussion along the same line as suggested in Mr. Parker C. Choate's contribution to the July 1 issue of the *CHEMICAL & METALLURGICAL ENGINEERING*, the interrogation arises: What are the fundamental problems in the retort metallurgy of zinc? They appear to be:

First, zinc sulphide must be desulphurized.

Second, zinc ore must be reduced to the metal at a temperature which is above the boiling point of the metal at ordinary pressure.

Third, the metal after reduction must be condensed to the liquid form. In so doing the very troublesome blue-powder is formed.

Making refined zinc is a different field, not being considered at present in the discussion. However, if the refined zinc is primarily or finally produced by retorting, the above three fundamental problems enter into its production.

Dismissing the subject of roasting as being a field by itself and not considering the lime-reduction process for the present, the subject resolves itself into the second and third problems, namely, reduction and condensation.

In regard to reduction in a furnace using vertical retorts mechanically fed and discharged, there could be no more difficulty than in the ordinary type of retort. An idea for changing the retort would be to have a central core connected with a plunger which would raise the retort out of the combustion chamber when a change was needed. The matter of briquetting could also be worked out for this type of retort. In the issue of *METALLURGICAL & CHEMICAL ENGINEERING* for June 1, 1916, was published a description with a cut of such a

furnace being operated in Germany. It would not be surprising if some such research had been conducted in Belgium before the war.

As to condensation and the formation of blue-powder using a vertical retort, the conditions would seem to be more favorable to success than with the continuous electrothermic furnace with which a great deal of trouble was experienced along this line, for small units would still be used.

From a theoretical standpoint the metallurgical difficulties arising in reduction and condensation would be fewer in the vertical than in the old style retort. The principal inventions would have to be in devices for feeding and discharging the retorts.

The best process is the most economical. The most economical is the one with the least cost as to labor, maintenance, and fuel. In choosing a process it is necessary to nicely balance the three items of cost, one against the other. If the vertical type of retort with mechanical equipment is adopted, the labor cost will be reduced and the maintenance cost will increase. But it is doubtful if the increase of upkeep cost will overbalance the decrease in labor cost. This is a natural trend in all industries, and it seems that the zinc smelters should be doing profitable research work along this line.

In regard to the third item of cost, fuel, a question arises whether it will be easier to conserve fuel in using the old retort process or the vertical retort and mechanical equipment. It would appear that the latter would be more favorable for the reduction of fuel expense, because to reduce the extraneous coal, gas must be burned in small burners and thus be better controlled. To do this there must be conditions that call for uniform heat continuously. This will also allow the gas formed in reduction of the charge to be recovered from the condenser and used for fuel, as the temperature being uniform at all times the furnace man will not need to leave the gas burning at the end of the condenser to show how the furnace is running by the way it "lights up."

The conclusions are that the continuous process with the use of vertical retorts and a mechanical equipment will reduce the labor and fuel expense and increase the maintenance, but that it will result in a cheaper process, since the reduction of the two items of expense will more than balance the increase in the one.

J. H. HASTINGS.

Donora, Pa.

## Sugar Consumed by the Allies

The Food Administration has authorized publication of the annual statistics on sugar given below. It will be noted that America uses sixty per cent of this "human fuel" at a price very much below the average for Europe.

|                      | Tons Consumption | Price | Value         |
|----------------------|------------------|-------|---------------|
| United States .....  | 4,109,300        | \$146 | \$681,956,500 |
| United Kingdom ..... | 1,565,600        | 252   | 394,531,000   |
| France .....         | 370,600          | 246   | 140,372,766   |
| Canada .....         | 352,200          | 166   | 58,465,200    |
| Italy .....          | 277,000          | 526   | 145,667,300   |

The refiners now receive \$26 per ton for refining, which is perhaps the lowest rate for an equivalent amount of processing in the chemical industry. Large production makes this possible.

## Western Chemical and Metallurgical Field

### Tungsten Production, Imports and Requirements

AT THE conference held in San Francisco June 28 between the Tariff Commission and those interested in the production of tungsten, Mr. J. H. Mackenzie, of the Bureau of Mines, gave some interesting data on imports for 1917, together with data as to the origin and declared cost, c.i.f. New York. The imports of tungsten for 1917, figured to a basis of 60 per cent  $WO_3$  were:

| Origin                  | Amount (Tons) | Cost per Unit |
|-------------------------|---------------|---------------|
| Hong Kong               | 32            |               |
| China, other than above | 196           | \$11.60       |
| Siam                    | 28            |               |
| Japan                   | 603           | 17.70         |
| Mexican                 | 340           | 8.70          |
| Portugal                | 120           |               |
| Argentina               | 215           | 19.00         |
| Chile                   | 1,930         |               |
| Peru                    | 1,200         |               |
| Panama                  | 159           | 15.75         |
| Equador                 | 11            |               |
| Bolivia                 | 45            |               |
| South Africa            | 1             |               |
|                         | 4,880         |               |

It was understood that the Chinese production came mostly from the interior; Japanese imports largely originated from Manchuria and Korea, and possibly were in part byproducts of other milling operations. Little information as to the origin of the Mexican importations was available, but on account of its low price, it was suggested that at least some of it represented loot acquired by Sonora bandits. The exports from the ports of Chile, Peru, Panama and Equador were largely of Bolivian origin, where much of the production is won from placers. Portugal produces about 3000 tons of concentrate yearly—probably 1000 tons of this is smuggled into Spain and thence into Germany as this amount seems to be lost to regular trade channels.

The three large producers of tungsten are Burma, Bolivia and the United States, each with about an equal volume. The entire Burmese output goes to England, which government has recently raised the price from 55 to 60 shillings, as the cost c.i.f. Liverpool is quoted at \$15.25 per unit. The Siamese and Burmese deposits are quite similar, and on account of proximity may be extensions of the same mineralized horizon. The tungsten is mainly brought in by Chinese and Japanese coolies who go into the interior and collect the rich surface ore running as high as 70 to 75 per cent  $WO_3$ . The labor cost is very low—in the interior Chinese boys of 14 or 15 being had for about \$2.00 per month. The government tax is high, being from 30 to 40 per cent of the value, depending largely upon how many officials see it. Transportation and the sacks represent the balance of the importing cost, which would be from \$15.00 to \$17.00 per unit in the States.

Mr Mackenzie also tabulated the United States production (basis 60 per cent  $WO_3$ ):

|      | Tons                   |
|------|------------------------|
| 1908 | 671                    |
| 1909 | 1,619                  |
| 1910 | 1,821                  |
| 1911 | 1,339                  |
| 1912 | 1,330                  |
| 1913 | 1,537                  |
| 1914 | 990                    |
| 1915 | 2,352                  |
| 1916 | 5,849                  |
| 1917 | 4,800 or a little more |
| 1918 | 4,250 estimated        |

As shown, he thinks our probable production will be a little less this year than last, with greater imports.

The latter amounted to 595.5 tons per month for the first quarter of 1918, largely from South America, China and Japan, as compared to the monthly average of 400 tons in 1917. If production and importation is maintained at the above figures the available supplies of 60 per cent concentrates for 1918 will amount to 11,400 tons, against an estimated consumption of 11,975 tons.

Reports from sixteen large producers show their stock on hand as of May 1, 1917 and 1918, as follows:

|                                            | May 1, 1917<br>Pounds | On Hand<br>May 1, 1918<br>Pounds | Increase<br>Per Cent |
|--------------------------------------------|-----------------------|----------------------------------|----------------------|
| 70 per cent ferro-tungsten                 | 517,172               | 545,575                          | 5                    |
| Ore and concentrates                       | 1,134,379             | 2,370,219                        | 52                   |
| High speed steel                           | 3,555,257             | 5,269,958                        | 33                   |
| The total equivalent to 60 per cent $WO_3$ | 3,690,720             | 5,757,640                        | 36                   |

The main use for this metal is in the manufacture of high-speed steels, for which there is no substitute known. Valve stems and seats for aeroplane engines bid fair to absorb a considerable tonnage. Probably other quantities are absorbed in gun tubes, although information as to such uses is naturally scarce. Molybdenum has often been spoken of as a substitute for tungsten; however, Taylor's original work condemned molybdenum as a constituent in high-speed steel, as has recent British and French ordnance tests. These results are possibly largely responsible for the present dull market in tungsten substitutes.

### The Pacific Electro Metals Company

IT IS very natural for the Pacific Coast to become interested in electrometallurgy. The coastal regions, especially the California part, are well mineralized with various ores suitable for reduction in the electric furnace. Much hydro-electric power is already developed

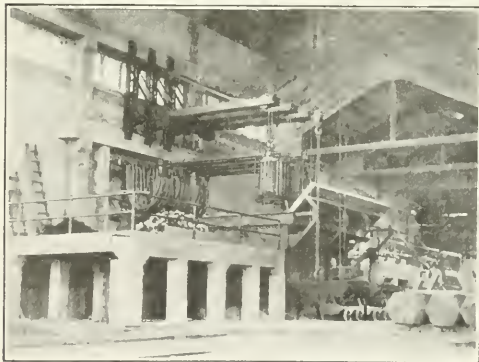


FIG. 1 FERRO-SILICON FURNACE

and there are still large amounts of undeveloped power available comparatively close to tidewater. The Pacific Electro Metals Company has taken advantage of these conditions; the fact that it is being financed by a group of local men is an indication that the Pacific Coast is becoming awakened to the possibilities of new development aside from mining and agriculture. Its situation at Bay Point, Cal., is peculiarly fortunate in regard to transportation facilities, being served by two transcontinental railways as well as by deep-water navigation in Suisun Bay.

At the present time the furnace shown in Fig. 1 is in operation making a steel deoxidizer called silico-manganese of about the following analysis:

|    | Per Cent                 |
|----|--------------------------|
| Si | 20 to 25                 |
| Mn | 50 to 55                 |
| P  | 0.1                      |
| S  | Trace                    |
| C  | Less than 1, usually 0.5 |
| Fe | Balance                  |

The charge consists largely of a silicious ore of manganese, reduction being effected by the carbonaceous residue which was obtained from oil-gas works in the vicinity.

As shown in the illustration, the electric furnace is a three-phase furnace with an open top, lined with firebrick and carbon. Raw materials are kept heaped by shovel and rake around the electrodes, while the metal and slag are tapped at 2-hour intervals into sand beds formed in the car bodies, shown directly in front of the furnace. The operation of smelting is thus a continuous one. Transformer equipment for one furnace is composed of four single-phase, 1000-kw. transformers, one of which is a spare. The high tension current approximates a voltage of about 23,000, while the current fed to the furnace is in the neighborhood of 70 volts. The transformer room is a substantially built, reinforced-concrete addition immediately behind the furnace. Carbon electrodes are used and are 24 inches, round or hexagon. The holders are raised from time to time as the electrodes are consumed and the water-cooled clamps approach the ore charge, this operation consuming only about 10 minutes. Splicing being impracticable, the butt ends are reformed into the hexagonal electrodes stacked on the furnace room floor as in the illustration. This work is done in a well-equipped plant on the property. Much experimental work on a large scale has been done in this plant leading to the utilization of the gas-house carbon as a raw material for electrodes.

A second furnace of the same design is under construction in which ferro-manganese or silico-manganese will be made, according to the market. The furnace, transformer, packing and electrode buildings are all substantially built of concrete and impress the casual visitor very favorably. The site also contains warehouse, office, laboratory and other auxiliary buildings. The company has erected a colony of attractive cottages for their operators in the town of Bay Point.

Mr. J. Grotzinger is general superintendent of the company and in charge of the smelting operations. The plant was built during the last 12 months under the direction of the consulting engineers of the company, The Beckman & Linden Engineering Corporation of San Francisco, California.

**American Smelting and Refining Company.**—This company enjoyed a gross income of \$31,602,615 during the year ending Dec. 31, 1917, a record year, exceeding the maximum corresponding value by nearly three and one half millions. Net earnings applicable to dividends amounted to \$18,495,625 or 22½ per cent on common stock, after preferred dividends had been deducted. In the face of these returns, President Daniel Guggenheim notes that the peak price of metals was passed during the first half of the year, while costs of materials and labor are yet rising, and remarks: "By these two Governmental actions, first by reducing the value of our

product, and second, by constantly increasing our cost, this great corporation, producing what is absolutely necessary to the Government in carrying on the war, is having its ability to pay a fair return to its stockholders seriously jeopardized." During the year approximately \$4,700,000 was expended in extensions to smelters at Garfield, El Paso, and Hayden, and refineries at Baltimore, Perth Amboy and Tacoma, bringing the total capacity up to 1,150,000,000 pounds of electrolytic copper per year. An appropriation of \$6,000,000 was made for plant extensions and betterments during the year 1917, and the property account is now valued at \$136,797,476. During the year, the company added one more zinc plant to its operations located at Henryetta, Oklahoma. Poor railroad deliveries have resulted in a lock-up of values amounting to many million dollars, while severe weather and a shortage of labor have increased the difficulties of operation. Safety work costing \$160,000 has resulted in a 25 per cent decrease in the number of fatal accidents, a decrease of 451 disabling accidents, and a 5274-day decrease in time lost through temporary disability. The system of visiting nurses has been extended during the year, who visit workmen's homes, particularly in time of sickness, to instruct the mothers in the proper care of the family. Children's classes in sanitation and hygiene have also been organized.

#### OPERATING STATISTICS

|                                            | 1916          | 1917          |
|--------------------------------------------|---------------|---------------|
| Number of men employees, excluding Mexico  | 21,073        | 24,698        |
| Total wages and salaries, excluding Mexico | \$17,047,944  | \$24,497,836  |
| Average wages per 8-hour day               | \$2.70        | \$3.31        |
| Tons charge smelted                        | 4,789,474     | 5,918,924     |
| Tons bullion refined                       | 677,460       | 706,875       |
| Tons coal used                             | 724,595       | 787,890       |
| Tons coke used                             | 4,468         | 592,765       |
| Barrel fuel oil used                       | 1,107,285     | 1,560,555     |
| Cubic feet gas used                        | 2,130,460,328 | 3,032,908,373 |
| Tons ore mined                             | 1,638,566     | 2,318,925     |
| Tons coal mined                            | 244,807       | 259,490       |
| Tons coke produced                         | 140,961       | 186,107       |

#### METAL PRODUCTS

|                                        | 1916        | 1917        |
|----------------------------------------|-------------|-------------|
| Ounces gold produced                   | 2,662,011   | 2,496,693   |
| Ounces silver produced                 | 71,868,451  | 69,841,061  |
| Ounces platinum and palladium produced | 868         | 1,597       |
| Tons lead produced                     | 275,144     | 275,266     |
| Pounds copper produced                 | 789,438,000 | 848,888,000 |
| Pounds best select copper produced     | 42,807,547  | 66,086,000  |
| Pounds spelter produced                | 1,224,328   | 52,522,000  |
| Pounds nickel produced                 | 4,522,000   | 682,715     |
| Pounds tin produced                    | 4,522,000   | 12,130,000  |
| Pounds sulphuric acid produced         | 25,842,000  | 66,174,000  |
| Pounds arsenic produced                | 9,090,000   | 9,132,000   |
| Pounds copper sulphate produced        | 13,046,000  | 7,598,000   |
| Pounds by-product metals               | 5,671,827   | 4,131,709   |
| Pounds copper and brass manufactured   | 31,597,489  | 39,767,274  |
| Pounds steel lead and litharge sold    | 417,898     | 426,477     |
| Number loaded cartridges sold          | 15,338,000  | 14,180,000  |
| Pounds sheet lead, pipe, etc., sold    | 21,713,331  | 13,678,245  |
| Pounds mixed metals sold               | 2,631,617   | 5,168,045   |

### Graphite Crucibles Placed on List of Restricted Imports

The War Trade Board has placed graphite crucibles upon the list of restricted imports. All outstanding licenses for the importation of graphite crucibles have been revoked as to ocean shipments after July 15, 1918, and no licenses for the importation of this commodity for shipment after that date will be granted for the rest of the calendar year. Imports of graphite are already prohibited, the result of this restriction having been to develop an adequate supply of graphite within the country. The action of the War Trade Board in restricting the importation of graphite crucibles is complementary to the restriction upon the importation of graphite.



## Alien Property Custodian Seizes Metal Concerns

IT WAS announced on July 22 that the Alien Property Custodian had seized the property of L. Vogelstein & Co., Beer, Sondheimer & Co., and other minor organizations engaged in the metal industry. These were German-owned firms which exercised a large influence in the world's metal business. According to the Alien Property Custodian these firms had taken advantage of certain legal advice which had enabled them to masquerade as American firms so successfully that months of investigation were required to prove enemy ownership. Both of the seized corporations had made reports stating that they were American-owned, but apparently the Americanization was only a surface effect designed to hide German ownership. The following statement was issued by the Alien Property Custodian: "With the American Metals Company, the large enemy interest in which has already been taken over by the Alien Property Custodian, Beer, Sondheimer & Co. and L. Vogelstein & Co. controlled most of the principal metal and smelting companies of this country, either by complete ownership of stock or by the ownership of enough stock to give them substantial representation on the Boards of Directors.

"Beer, Sondheimer & Co. own a one-half interest in the National Zinc Company, the entire stock of the Cuba Copper Company, the Cuba Copper Leasing Company, and the Norfolk Smelting Company, 30,000 shares of the Minerals Separation American Syndicate, Limited.

"Vogelstein & Co. have large holdings in the United States Metal Refining Company and the Kansas Zinc and Smelting Company. Of the 70,000 shares of capital stock of the American Metals Company, 15,180 shares are owned by the Metallbank and M. C. of Frankfurt-am-Main and 18,180 shares by the Metallgesellschaft of the same place.

"The American Metals Company completely owns the following companies: American Zinc and Chemical Company, Langeloth Coal Company, Langeloth Mercantile Company, Langeloth Townsite Company, American Metal Transport Company, Bartlesville Zinc Company, and South American Metal Company. It had large holdings of stock in the following companies: Ohio and Colorado Smelting and Refining Company, Compania Minera de Penoles, South America; Compania de Minerales y Metales, South America; Compania Metalurgica de Torreon, South America; Compania Minero Palome y Gabrillas, South America; Compania de Combustibles Agujita, South America; Fundicion de Guayaca, South America; Balbach Smelting and Refining Company, and Nichols Copper Company.

"In 1914 the profits of Beer, Sondheimer & Co. were \$116,624; in 1915 the profits of this concern jumped to \$1,013,676, and in 1916 they reached the large total of \$2,000,000. In 1917, after the United States got into the war, the profits dropped to \$196,900.

"The profits of L. Vogelstein & Co. since April, 1916, were extremely large, the firm's business for the last three years approximating \$70,000,000 a year. Between April and December of 1916 the profits of Vogelstein & Co. amounted to upward of \$2,500,000.

"To make these concerns 100 per cent American, the Alien Property Custodian has appointed as Directors Americans who are well known in the business and financial life of the country.

"The Directors named for Vogelstein & Co. are:

EDWARD M. McILVAIN, former President of the Bethlehem Steel Company.

LOUIS A. WATRES, President of the Scranton Trust Company and former Lieutenant Governor of Pennsylvania.

JAMES N. WALLACE, President of the Central Trust Company of New York.

ALFRED H. SMITH, President of the New York Board of Aldermen.

C. C. DANIELS of New York City.

"The Alien Property Custodian will allow Paul L. Vogelstein and Ernest Hethern to act as Directors also; Isidor J. Kresel, 37 Wall Street, New York City, will act as counsel for this company.

"Messrs. Wallace, McIlvain, and Watres will also act as Directors of Beer, Sondheimer & Co., in addition to John P. Greer, 15 Broad Street, New York City, and Ford Huntington, 15 Dey Street, New York City. Benno Elkan and Otto Frohnecht will act with the above Directors. Joseph E. Davies, former President of the Federal Trade Commission, and Isidor Kresel will act as counsel for this company.

### DIRECTORS FOR AMERICAN METALS CO.

"The Directors whom the Alien Property Custodian has selected to represent the enemy interest in the American Metals Company are:

HENRY MORGENTHAU, Former Ambassador to Turkey.

ANDREW W. MALLON of Pittsburgh.

GEORGE MCANENY of New York City.

LEWIS L. CLARK of the American National Bank of New York.

E. C. CONVERSE of the Bankers Trust Company of New York.

"John J. Fitzgerald will act as counsel. Mr. Wallace, with Francis P. Garvin, have been chosen by the Alien Property Custodian to act as Directors for Stallforth & Co."

## Government Controls Chlorine Production and Distribution

The War Industries Board authorizes the following: Owing to the shortage of chlorine in the United States, the War Industries Board, with the approval of the President, has passed a resolution taking over control of its production and distribution. For the present, however, the board is doing no more than allocate the product, and this is being done under the direction of H. G. Carrell, chief of the Alkali and Chlorine Section of the War Industries Board.

Chlorine has a wide range of uses, the most important from the present Government point of view being in the manufacture of gas shells and in carbon tetrachloride, which is the basis of one of the most effective smoke screens and also of the best fire extinguishers.

One of the most important commercial uses of chlorine is in the bleaching of paper and various cloth fabrics.

## Platinum as Seen by the Jeweler and the Chemist

AT THE hearing with reference to the new revenue bill, held before the Committee on Ways and Means at Washington on July 10 and 11, the subject of platinum received considerable attention. It developed however, that most of the testimony resolved itself into a controversy between the jeweler and the chemist, rather than enlightening the Ways and Means Committee as to methods of deriving revenue by taxing platinum.

MR. MEYER C. ROTHSCHILD of New York City, representing sixty-two jewelry organizations in the United States, appeared before the committee on behalf of the jewelers. Much of his testimony was devoted to a reply to a speech made by the Honorable Henry T. Rainey, of the Committee on Ways and Means, on the floor of the House of Representatives on June 7. Mr. Rothschild felt that Mr. Rainey had put the jewelers in the wrong light before the country. He also felt that the campaign conducted by the American Chemical Society through the *Journal of Industrial and Engineering Chemistry* had misrepresented the platinum situation as far as jewelers were concerned with it. He stated that the Jewelers' War Service Committee had called on the War Industries Board at Washington, and had recommended that all unmanufactured platinum held by jewelers be commandeered. The War Industries Board, however, felt that this would seriously disturb the jewelry industry and consequently they commandeered 75 per cent of the stock of unmanufactured platinum in the hands of jewelers, after having been unsuccessful in getting the jewelers to give up their stock voluntarily. Mr. Rothschild took the position that the government should have commandeered platinum long before it did, taking no chances in regard to having an adequate supply. In cross examination of Mr. Rothschild, Congressman Longworth introduced a copy of a jewelry magazine showing full-page advertisements in which platinum jewelry was featured. The advertisements were cited as an example of what had not been accomplished in the direction of preventing advertisements of platinum jewelry.

Whatever may be the merits or the demerits of the jewelers' attitude, Mr. Rothschild made some remarks in regard to the attitude of the War Industries Board in fixing a price of \$90 per ounce for platinum when it was selling in the open market in New York at \$105.

Mr. Rothschild pointed out that but for the unbusinesslike attitude of the War Industries Board, the United States might easily have secured additional platinum supplies from Russia. This, however, was impossible when a price of but \$90 per ounce was paid for some 21,000 ounces which was brought over here at great risk. Mr. Rothschild was of the opinion that there was about one million ounces of platinum now in the country, of which the jewelers held a stock of about 5000 ounces on February 1, 1918.

DR. CHAS. H. HERTY, editor of the *Journal of Industrial Engineering Chemistry* appeared before the committee to correct certain erroneous impressions which he felt were created by Mr. Rothschild. Doctor Herty pointed out particularly that the movement started by the American Chemical Society for the conservation of platinum was not a propaganda on the part of a few

chemists, but the action of an important organization embracing about 12,000 chemists in every part of the country. Doctor Herty showed the essential nature of platinum in the chemical industry and its unessential use in jewelry, particularly in war time, and defended very well his entire editorial campaign against such use of the metal.

On the question of taxation of platinum, it was Dr. Herty's opinion that there should be none of the metal available for taxation; that the Government should purchase the entire supply in this country and place it in the vaults of the Treasury for Government needs. He pointed out that there was a great deal of manufactured platinum jewelry in this country today, which could easily be bought by pro-German interests and transmitted to Germany in a round-about way.

DR. LOUIS J. WEINSTEIN of the Dental Department of Columbia University, also appeared before the Ways and Means Committee, with regard to the use of platinum in the dental business. He was of the opinion that the dentists of the United States use about 20,000 ounces of platinum per year, but that this quantity could be reduced very materially through the use of substitutes. He felt that on a request coming from an authoritative source, the use of platinum could be cut down so that only one-fourth of the customary amount would be used in dentistry, which would release about 15,000 ounces per year for other purposes.

MR. LELAND L. SUMMERS of the War Industries Board appeared before the Committee to refute the inference carried by previous testimony that the War Industries Board "has been incompetent and asleep, and that the military program of the Government has been imperiled" thereby.

Mr. Summers explained the Board's policy in fixing \$90 per ounce as the price to be paid for the 21,000 oz. of Russian platinum by saying that the British Government official price was only \$65 per oz. and that our Government commandeered the Russian lot at \$90 with the understanding that those who had furnished the platinum could go before the Court of Claims or the Board of Appraisers and get more if they could show that \$90 was not a fair price.

Mr. Summers upset all previous testimony by saying that the agitation about platinum has been overdone; that he was not distressed as to where the platinum is coming from; and that substitutes could be used just as they have been elsewhere. He stated emphatically that "we are not up against any crisis." The War Industries Board now controls 40,000 oz. of platinum, and apparent requirements on March 1, 1918 were 37,000 oz. and today about 55,000 oz. The apparent shortage can be provided by supplies from Colombia, 10,000 oz. from Great Britain, and by extending the commandeering orders not only to the jewelry trade but also to the dental and chemical professions. With regard to substitutes for platinum for making sulphuric acid, Mr. Summers stated that "we are getting very satisfactory results from preliminary experiments that have been undertaken."

With regard to further extension of the commandeering orders, Mr. Summers said that by including the chemical and dental industries and the balance of the jewelers, provision would be made for our requirements well into 1920.

## New Government Agency Taking Census of Industries

To meet the constantly increasing demands of the Government for new resources and to supply the War needs of the Army and Navy and other Government departments, the War Industries Board has created the Resources and Conversion Section.

The primary object of this new section is to assemble as quickly as possible complete and detailed information concerning industries in all parts of the country:

- (a) Those not now engaged in war work but capable of undertaking such work.
- (b) Concerning industries only partly employed on war work but able to increase their production of necessary war materials, and
- (c) Industries now employed on war work whose contracts will soon be complete.

To accomplish this in the most efficient way it has been decided to divide the country into regions and organize them thoroughly under the leadership and with the co-operation of the local Chambers of Commerce and other business men's organizations.

It is desired to enlist the aid of all classes of industry, and to bring this about it is imperative that all

As an indication of what is possible in the conversion of industry to meet war requirements and of the changes which can be made in the product of a factory, a few radical instances serve to illustrate. For instance, a Pennsylvania factory that formerly made linoleum is now machining 4.7-inch shells. A Duluth horseshoe manufacturer is turning out trench picks for the Army, and a New Jersey terra-cotta tile concern is making dummy drop bombs. A Milwaukee factory, the former output of which was rowboat motors, is making hand grenades and trench pumps. In Rhode Island, a manufacturer of finger rings has returned his activities to making adapter plugs. A Detroit stove concern is producing trench bombs and anchor parts, and a New York shirtwaist manufacturer is making signal flags.

## Corporation Organized to Sell Enemy-Owned Property

The formation of a selling corporation to control and sell all German-owned corporations taken over by the Alien Property Custodian has been announced at Washington. This selling corporation will have complete control over the sale of nearly 150 enemy-owned corporations now in the custody of the Alien Property Custodian, valued at about \$250,000,000.

In addition to the Alien Property Custodian the new selling organization will consist of a Washington committee, an advisory committee in New York, a sales manager in New York, representatives of the Alien Property Custodian in charge of each property to be sold, and an attorney representing the Alien Property Custodian in respect of each property to be sold. Sales will be made at public auction whenever it is possible to do so, and unless the Advisory Committee recommends different procedure. This applies not only to sales by the Alien Property Custodian, but also to sales by and in the name of

corporations controlled by him. The expenses of each sale, which shall include all expenses and costs of every kind, shall be paid out of the funds of the specific property sold, or out of the purchase money received from such sale, or deducted from the purchase price.



UNITED STATES INDUSTRIAL REGIONS

the industries of a given region should be asked to participate whether they are now members of business organizations or not.

The twenty regions and the regional representatives appointed are:

| Region No. | Region        | Name                 |
|------------|---------------|----------------------|
| 1          | Boston        | Stuart W. Webb       |
| 2          | Bridgeport    | B. D. Pierce, Jr.    |
| 3          | New York      | Wm. F. Morgan        |
| 4          | Philadelphia  | Ernest T. Trigg      |
| 5          | Pittsburgh    | George S. Oliver     |
| 6          | Rochester     | Eaton A. Fletcher    |
| 7          | Cleveland     | Win. B. McAllister   |
| 8          | Detroit       | A. H. Templeton      |
| 9          | Chicago       | D. F. Felt           |
| 10         | Cincinnati    | Edwin C. Gibbs       |
| 11         | Baltimore     |                      |
| 12         | Atlanta       |                      |
| 13         | Birmingham    | T. H. Aldrich        |
| 14         | Kansas City   | F. D. Crabbs         |
| 15         | St. Louis     | Jackson Johnson      |
| 16         | St. Paul      |                      |
| 17         | Milwaukee     | August H. Vogel      |
| 18         | Dallas        | Louis Lipsitz        |
| 19         | San Francisco | Frederick J. Koester |
| 20         | Seattle       |                      |

## Instruction and Research in Industrial Hygiene at the Harvard Medical School

Through the foresight and generosity of a group of New England manufacturers, who appreciated the importance of studying the diseases peculiar to factory labor, special courses have been arranged, which will be given in the School of Public Health. Those properly qualified may matriculate for the degree of Doctor of Public Health (Dr. P.H.). For information apply to Dr. C. K. Drinker, Harvard Medical School, Boston, Mass.



## Distribution of Niagara Power

INTERVENTION by the United States in the control and distribution of power generated in this country in the Niagara Falls district and that imported from Canada has resulted in accurate knowledge of the uses of that power. In a report recently made to Secretary Baker by Brig. Gen. Charles Keller and Robert J. Bulkley, it is shown that practically all the power available is used to the advantage of the prosecution of the war, as appears in Table I.

TABLE I—THE USAGE OF ELECTRIC ENERGY AS PRODUCED DURING A TYPICAL PERIOD IN THE WINTER OF 1917-1918

|                                                              | Niagara Falls Power Co. | Hydraulic Power Co.        | Niagara, Lockport & Ontario Power Co. | Buffalo General Electric Co. |
|--------------------------------------------------------------|-------------------------|----------------------------|---------------------------------------|------------------------------|
|                                                              |                         | Percentage of Total Output | Power Company                         |                              |
| Direct war industries.....                                   | 73.53                   | 97.05                      | 58.31                                 | 50.27                        |
| Transportation purposes....                                  | 11.55                   | .....                      | 21.21                                 | 21.47                        |
| Street, commercial and residence lighting, water supply..... | 7.81                    | 1.95                       | 7.61                                  | 13.99                        |
| Commercial power consumers over 100 H.P.....                 | 1.52                    | 0.13                       | 5.94                                  | 2.82                         |
| Small commercial power....                                   | 3.61                    | 0.78                       | 6.80                                  | 7.49                         |
| Non-essential purposes.....                                  | 1.98                    | 0.09                       | 0.13                                  | 3.96                         |

Table II shows not only the increased allotments of power to the essential electrochemical industries in the Niagara district, but also the average amounts of

entials as ferrosilicon, electrodes, phosphorus, chlorine, and abrasives.

TABLE IV—DISTRIBUTION OF ELECTRIC POWER OF THE NIAGARA FALLS POWER COMPANY OF NIAGARA FALLS BEFORE AND AFTER APPLICATION OF ORDER OF THE SECRETARY OF WAR, DECEMBER 28

| Name of Company Taking Power     | Use of Power, Nov., '17 | Reapportionment of Power, Increase |                    | Distribution of Power, Mar., '18 |
|----------------------------------|-------------------------|------------------------------------|--------------------|----------------------------------|
|                                  |                         | Hp.                                | Decrease Hp.       |                                  |
| Buffalo General Electric Co..... | 35,282                  | .....                              | 9,100              | 26,182                           |
| Niagara River Mfg. Co.....       | 880                     | .....                              | 880                | 0                                |
| International Paper Co.....      | 3,000                   | .....                              | 3,000 <sup>1</sup> | 0                                |
| Acheson Graphite Co.....         | 5,408                   | 2,500                              | .....              | 7,908                            |
| Hooker Electrochemical Co.....   | 9,165                   | .....                              | .....              | 9,165                            |
| Iaco Chemical Co.....            | 709                     | .....                              | .....              | 709                              |
| Mathieson Alkali Co.....         | 10,343                  | 1,407                              | .....              | 11,750                           |
| Niagara Electrochemical Co.....  | 9,506                   | 4,000                              | .....              | 13,506                           |
| Niagara Alkali Co.....           | 1,363                   | .....                              | .....              | 1,363                            |
| Oldbury Electrochemical Co.....  | 2,654                   | .....                              | .....              | 2,654                            |
| Star Electrode Works.....        | 4,083                   | 1,600                              | .....              | 5,683                            |
| Carborundum Co.....              | 10,483                  | 2,217                              | .....              | 12,700                           |
| Union Carbide Co.....            | 6,233                   | 1,256                              | .....              | 17,789                           |
| Others smaller companies.....    | 23,935                  | .....                              | .....              | 23,935                           |
|                                  | 133,344                 | 12,980                             | 12,980             | 133,344                          |

<sup>1</sup> Later returned to Paper Company when it began manufacture of ferrosilicon.

## Mining Engineers Meet in Colorado in September

The American Institute of Mining Engineers will hold its regular Fall meeting in Colorado during the week of Sept. 2. The sessions will open in Denver on Sept. 2, after which headquarters will be at Colorado Springs.

TABLE II—NIAGARA FALLS—BUFFALO DISTRICT INCREASED ALLOTMENTS OF POWER TO ELECTROCHEMICAL INDUSTRIES IN APRIL 1918, AS COMPARED WITH POWER USED IN NOVEMBER, 1917, UNDER NORMAL CONDITIONS

| Product Manufacturer            | Ferrosilicon |                    | Electrodes |           | Silicon   |           | Phosphorus, Etc. Sodium-Cyanide |           | Chlorine, Etc. |           |
|---------------------------------|--------------|--------------------|------------|-----------|-----------|-----------|---------------------------------|-----------|----------------|-----------|
|                                 | Nov., '17    | Apr., '18          | Nov., '17  | Apr., '18 | Nov., '17 | Apr., '18 | Nov., '17                       | Apr., '18 | Nov., '17      | Apr., '18 |
|                                 | Hp.          | Hp.                | Hp.        | Hp.       | Hp.       | Hp.       | Hp.                             | Hp.       | Hp.            | Hp.       |
| Union Carbide Co.....           | 66,867       | 78,964             | .....      | .....     | .....     | .....     | .....                           | .....     | .....          | .....     |
| Defiance Paper Co.....          | .....        | 2,034 <sup>1</sup> | .....      | .....     | .....     | .....     | .....                           | .....     | .....          | .....     |
| International Paper Co.....     | .....        | 3,000              | .....      | .....     | .....     | .....     | .....                           | .....     | .....          | .....     |
| U. S. Alloys Company.....       | 6,720        | 9,176              | .....      | .....     | .....     | .....     | .....                           | .....     | .....          | .....     |
|                                 | 73,587       | 93,174             | .....      | .....     | .....     | .....     | .....                           | .....     | .....          | .....     |
| Increase.....                   | .....        | 19,587             | .....      | .....     | .....     | .....     | .....                           | .....     | .....          | .....     |
| National Carbon Company.....    | .....        | .....              | 2,577      | 4,761     | .....     | .....     | .....                           | .....     | .....          | .....     |
| Int. Ach. Graphite Co.....      | .....        | .....              | 5,408      | 7,908     | .....     | .....     | .....                           | .....     | .....          | .....     |
| Star Electrode Works.....       | .....        | .....              | 4,083      | 5,683     | .....     | .....     | .....                           | .....     | .....          | .....     |
|                                 | .....        | .....              | 12,068     | 18,352    | .....     | .....     | .....                           | .....     | .....          | .....     |
| Increase.....                   | .....        | .....              | 6,284      | .....     | 10,483    | 12,700    | .....                           | .....     | .....          | .....     |
| Carborundum Co. of America..... | .....        | .....              | .....      | .....     | .....     | 2,217     | .....                           | .....     | .....          | .....     |
| Increase.....                   | .....        | .....              | .....      | .....     | .....     | .....     | 5,654                           | 8,654     | .....          | .....     |
| Oldbury Electrochem. Co.....    | .....        | .....              | .....      | .....     | .....     | .....     | 9,506                           | 13,506    | .....          | .....     |
| Increase.....                   | .....        | .....              | .....      | .....     | .....     | .....     | .....                           | 4,000     | .....          | .....     |
| Niagara Electrochem. Co.....    | .....        | .....              | .....      | .....     | .....     | .....     | .....                           | .....     | 10,343         | 11,750    |
| Increase.....                   | .....        | .....              | .....      | .....     | .....     | .....     | .....                           | .....     | 1,300          | 19,00     |
| Mathieson Alk. Co.....          | .....        | .....              | .....      | .....     | .....     | .....     | .....                           | .....     | 7,077          | 7,377     |
| Iaco Chemical Co.....           | .....        | .....              | .....      | .....     | .....     | .....     | .....                           | .....     | 1,125          | 1,319     |
| Niagara Alkali Co.....          | .....        | .....              | .....      | .....     | .....     | .....     | .....                           | .....     | .....          | .....     |
| Niagara Smelting Co.....        | .....        | .....              | .....      | .....     | .....     | .....     | .....                           | .....     | .....          | .....     |
|                                 | .....        | .....              | .....      | .....     | .....     | .....     | .....                           | .....     | 19,845         | 22,346    |
| Increase.....                   | .....        | .....              | .....      | .....     | .....     | .....     | .....                           | .....     | .....          | 2,501     |
| Total increase.....             | .....        | .....              | .....      | .....     | .....     | .....     | .....                           | .....     | .....          | 37,589    |

<sup>1</sup> Used by Union Carbide Co. until Apr., when Paper Co. began Ferrosilicon manufacture. <sup>2</sup> Power supplied by Niagara, Lockport & Ontario Power Co.

power in use before January 1, 1918, and the average amounts now devoted to the production of such es-

TABLE III—DISTRIBUTION OF ELECTRIC POWER OF THE HYDRAULIC POWER COMPANY OF NIAGARA FALLS BEFORE AND AFTER APPLICATION OF ORDER OF THE SECRETARY OF WAR, DECEMBER 28

| Name of Company Taking Power    | Use of Power, Nov., '17 | Reapportionment of Power, Increase |                    | Distribution of Power, March, '18 |
|---------------------------------|-------------------------|------------------------------------|--------------------|-----------------------------------|
|                                 |                         | Hp.                                | Decrease Hp.       |                                   |
| Aluminum Company of America     | 63,866                  | .....                              | 6,000              | 59,866                            |
| Iaco Chemical Co.....           | 473                     | .....                              | 223                | 250                               |
| Chl. Paper Co.....              | 3,291                   | .....                              | 3,291              | 0                                 |
| Defiance Paper Co.....          | 2,034                   | .....                              | 2,034 <sup>1</sup> | 0                                 |
| Frontier Brick Co.....          | 36                      | .....                              | 36                 | 0                                 |
| General Abrasive Co.....        | 1,706                   | .....                              | .....              | 1,706                             |
| Nat'l Electrolytic Co.....      | 2,892                   | .....                              | .....              | 2,892                             |
| Union Carbide Co.....           | 37,000                  | 5,500                              | .....              | 42,500                            |
| Hooker Electrochemical Co.....  | 6,234                   | .....                              | 6,234              | .....                             |
| Iaco Chemical Co.....           | 291                     | 600                                | .....              | 1,191                             |
| National Carbon Co.....         | 2,477                   | 2,184                              | .....              | 4,761                             |
| Niagara Alkali Co.....          | 5,714                   | 300                                | .....              | 6,014                             |
| Oldbury Electrochemical Co..... | 3,000                   | 3,000                              | .....              | 6,000                             |
| U. S. Light & Heat Corp.....    | 1,319                   | .....                              | .....              | 1,319                             |
| Titanium Alloy Mfg. Co.....     | 7,074                   | .....                              | .....              | 7,074                             |
| Other smaller companies.....    | 4,514                   | .....                              | .....              | 4,514                             |
|                                 | 144,621                 | 11,584                             | 11,584             | 144,621                           |

<sup>1</sup> Later returned to Paper Company when it began manufacture of ferrosilicon

Trips will be made from that point to the Cripple Creek district, Pueblo, Leadville district and Boulder. The sections to be visited are rich in important war minerals and important in the manufacture of ferro-alloys. The committee in charge of the meeting comprises: Spencer Penrose, chairman; A. E. Carlton, chairman finance committee; George M. Taylor, vice-chairman; J. Dawson Hawkins, secretary. Denver committees: (Arrangement) Dave G. Miller, Frank Bulkley, Geo. E. Collins; (Entertainment) F. H. Bostwick, F. E. Shepard, Howland Bancroft, B. P. Morse, J. G. Perry; (Finance) T. B. Stearns, Richard A. Parker, T. B. Burbridge.

On July 1 670 officers and employees of H. M. Byllesby & Company and affiliated companies were engaged in the military service of the United States or Allies. This represents 13.8 per cent of all male employees. The service flag now bears four gold stars.

# The Metallography and Heat Treatment of Metals Used in Aëroplane Construction

Introduction to a Series of Articles Dealing With Cast Iron, Steel, Aluminium, Copper, Bronze, and Brass—Typical Examples of Investigations of Aëroplane Parts, With Microphotographs and Results of Physical and Chemical Tests

By F. GROTTES

Chief Metallurgist, Curtiss Aëroplane and Motor Corporation.

THE metals that are used in aëroplane construction are aluminium, copper, bronze, brass, cast iron and steel. Of these, steel has the most importance as more and important parts are made from it than from any of the other metals. It is divided into two classes, (a) carbon steel and (b) alloy steel to which has been added some particular element (Ni, Cr, V, etc.). The first division, carbon steel, is subdivided into low (0.15 per cent C), medium (0.32 per cent C) and high (0.9 per cent C); while the second division includes the nickel, chrome, vanadium, chrome-nickel and chrome-vanadium steels.

The structure and physical properties of these metals are greatly affected by the treatment or treatments, both mechanical and thermal, to which they have been subjected at the time of manufacture or after. As the structure and physical properties are of supreme importance it is necessary that they be investigated. This is done by certain tests, the best of which is a test to destruction, but this method is too expensive and time-consuming. Sometimes a practical field test will give all of the data necessary, but in order to judge whether or not a metal is suitable for the purpose for which it was intended, separate parts of the material are selected for test, and upon the results of these tests the metal is judged as a whole.

Chemical and physical tests give satisfactory data within certain limits, but they should be supplemented by metallographic tests which give information not obtainable by any other method. The particular use of metallographic testing is to give information in regard to the homogeneity of the metal, the heat treatment to which it has been subjected, and whether it has been subject to any strains.

## METHODS AND APPARATUS USED IN TESTING

In taking up the metallography and heat treatment of the materials before mentioned, the methods and apparatus will first be discussed.

**Preparation of Samples.** The samples used for metallographic examination are about one-half inch square or round. They are cut in most cases with a hacksaw, but hardened materials are cut with an emery wheel to the required size. Where the samples are too small to hold it is necessary to polish out to their edge; they are mounted in a section of tubing with solder or other low melting-point material. The tubing is about one-half inch long and one-half inch in diameter. The part to be mounted is placed in the center and the solder poured in the tube around it. This holds the specimen firmly and a good polish results.

**Polishing.** After taking the sample, all rough edges are removed with a file or emery cloth after which the section is ground down progressively from a coarse to fine emery belt and then, starting with No. 0 polishing paper, to No. 0000. At this point it is carefully examined to see if all scratches are removed; if so it is placed on a buffer covered with cloth and on which is placed some alumina and water. After this the specimen should be ready for the microscope.

### Rules for Polishing

1. Never overheat specimen and use light pressure.
2. Prevent the surface from becoming convex.
3. Turn specimen through 90 deg. after each separate operation and polish in the same direction during each operation.
4. Continue each step only long enough to eliminate the scratches of the previous operation.
5. Wash the specimens thoroughly between each operation to prevent particles of one abrasive from becoming mixed with the next and finer abrasive.
6. Keep all apparatus and solutions covered when not in operation. Fine particles, dust, sand, emery, etc., will spoil a half-day's work.
7. Use light pressure for aluminium, brass, bronze, etc., and in finishing on the buffer twist the specimen now and then to prevent smears or streaks in the direction of polishing.

**Etching.** Clean the section carefully with warm water and dry with alcohol. Immerse in the chosen solution for five seconds, ten seconds, etc., until etched properly. Clean with hot water and dry with alcohol. If the specimen is covered with a film, rub carefully on buffer and clean with alcohol. Etching solutions have the following composition: Nitric acid solutions of 10 cc. HNO<sub>3</sub> in 90 cc. alcohol and 20 cc. HNO<sub>3</sub> in 80 cc. alcohol are used. These solutions give good results but are not so good to show the structure for all steels in general as the following picric acid solution.

Picric acid: Saturated solution or about 10 grams of picric acid in 90 cc. of alcohol.

Sodium picrate: Two grams of picric acid is dissolved in 98 cc. of a solution of 250 grams of NaOH in 750 cc. of water. After boiling the polished specimen in this solution for 10 minutes, the ferrite remains bright while the cementite is dark colored.

Iodine: Tincture of iodine for copper, brass and aluminium, also to show strains in steel.

Copper ammonium chloride: For bronze and brass; 10 g. copper ammonium chloride, 15 cc. concentrated ammonium hydroxide, 250 cc. water.

**Heat Tinting.** Heat slowly until the specimen is colored yellow-brown, when the parts high in phosphorus will appear purple or blue.

**Sulphur Printing.** Velox printing paper soaked in a 3 per cent solution of sulphuric acid or 10 per cent hydrochloric acid solution is placed on the specimen for 20 seconds, washed in water and then fixed in hypo as are other prints. Sulphur shows black, due to the H<sub>2</sub>S given off from the reaction of the acid on the sulphide in the specimen. Care is taken to prevent specimen from slipping during printing operation.

#### PHOTOMICROGRAPHY

After polishing, the specimens are examined for slag, manganese, sulphide or pipes. The slag shows as dark irregular masses, the manganese sulphide as dove-colored oval-shaped bodies and the pipes as shown in Fig. 1.

After selecting the spot to be photographed, adjust the light carefully so as to get as bright and even

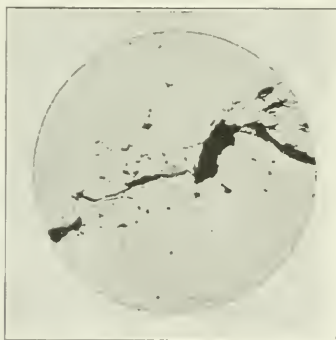


FIG. 1

illumination as possible. Focus the image as sharp as possible with the coarse adjustment and then finish with the fine adjustment.

**Exposure.** After the image is properly illuminated and focused, the plate is introduced and exposed. The length of exposure varies according to kind of plate, polish of specimen, power of illumination and color of screen (green, red, etc.). The plates used are panchromatic and Wratten "M" plates with green screen and electric arc illumination. The panchromatic plates are exposed for 15 seconds with the small orifice and the "M" plates for the same time with the next larger orifice.

**Development.** These plates are handled in an absolutely dark room and are developed for 15 minutes in Eastman developing powders 24-31-A-4 at a temperature of 65 deg., washed in cold water and immersed in fixing solution for 15 minutes.

Stock fixing solution

|                                        |     |
|----------------------------------------|-----|
| 384 oz., H <sub>2</sub> O              | } A |
| 96 oz., H <sub>2</sub> PO <sub>4</sub> |     |
| 30 oz., H <sub>2</sub> O               |     |
| 6 oz., Na <sub>2</sub> S               |     |
| 18 oz., Acetic acid                    |     |
| 6 oz., Alum                            | } B |

Add B to A slowly and stir vigorously.

After fixing, the plates are washed in running water for twenty minutes, then dried in a current of air.

**Printing Papers.** Velox regular glossy is used, printed for the necessary time to get the desired result, developed in solution of Eastman MQ developer at a temperature of 70 deg., washed in water and fixed in stock fixing solution for 15 minutes and then washed in running water for 20 minutes.

**Drying Papers.** A ferrotype tin is used which is first washed with water and dried with alcohol and then covered with a solution of beeswax in benzol. After drying, the surface of the tin is polished and the papers placed on it and rolled smooth. All moisture is removed with a blotting paper after which an electric fan soon dries the prints which drop from the tin and can be cut to the proper size and mounted.

#### HEAT TREATING

The object of heat treating is, first, to remove any stresses that might exist in the material; second, to refine and improve the structure; third, to cause a change in order to get the required physical properties. To understand these objects it is necessary to have considerable knowledge of the nature and composition of the metallic alloys. This is essential to an intelligent microscopic examination and heat treatment of any specimen of steel.

Steel is an alloy of various elements, the most important of which are carbon and iron. They go into solution at a high temperature while on cooling the constituents crystallize out in the form of octahedrons which have three cleavage planes showing in martensite.

In the heating and cooling of steel, certain phenomena are observed. For illustration; at one point, the steel becomes magnetic, and at another it seems to gain heat on cooling and actually glows. These points are called critical points and are shown by plotting cooling and heating curves.

**Critical Points.** In order to determine the proper heat-treating points, temperature curves are plotted which show the critical range. An easy method of procedure and accurate enough for most purposes is to take pieces of the material and place them firmly about a thermocouple in a furnace. As the heat rises, temperature readings are taken about every 10 seconds up to 1700 deg. F., which will take care of most steels. Plot the curve time and temperature, both heating and cooling. The material is quenched at about 100 deg. F. above the large break in the curve.

Where more accurate data are required, there is used a neutral body and a double thermocouple so connected that the difference of temperature between the metal under investigation and the neutral body is recorded as well as the actual temperature of the metal. This shows the critical range and whether there are one, two or three critical points. To distinguish critical points on cooling from those occurring on heating, the former are called Ar (from the French *refroidissement*, meaning cooling) and the latter Ac (from the French *chauffage*, heating). The points on heating are designated Ac, Ac<sub>1</sub>, Ac<sub>2</sub>, and on cooling as Ar<sub>1</sub>, Ar<sub>2</sub>, Ar<sub>3</sub>.

The Ar<sub>1</sub> points in the carbon steels used occur between 1250 and 1350 deg., and Ac<sub>1</sub> points about 75 to 100 deg. higher (all temperatures Fahrenheit). The critical points on cooling always lag behind the points on heating.



The critical points are due chiefly, if not wholly, to allotropic changes of the iron; and their great importance is due to the fact that the color, crystallization, dilation, conductivity for heat and electricity, strength, ductility, hardness and specific gravity of the steel are affected while passing through them.

There are three allotropic forms of iron: alpha, beta and gamma. Below the  $A_1$  point it is known as alpha which is magnetic, soft, and will not take any carbide into solution; between the  $A_1$  and  $A_2$  points is beta which dissolves carbide, is non-magnetic and harder than alpha iron. Above  $A_2$  is gamma which also dissolves carbide, is very hard and non-magnetic. The addition of different elements will influence the critical points. Manganese and nickel lower the critical points. Silicon and phosphorus go into solid solution with the ferrite and have no appreciable effect. Chromium and tungsten raise the critical temperatures and vanadium has no marked effect.

#### ANNEALING, HARDENING AND DRAWING OF STEEL

Steels are divided according to their carbon content into three classes: hypoeutectoid, below 0.89 per cent carbon; eutectoid, at 0.89 per cent; and hyper-eutectoid, above 0.89 per cent. The hypoeutectic class will cover most of the aeroplane steels. The medium carbon steel is a good illustration.

This material is generally in an annealed condition to start with, or a mixture of ferrite and pearlite. As heat is applied and the steel passes the  $A_1$  point, the constituents go into a solid solution consisting of iron carbide, cementite or a double carbide of iron and the special element, (Cr, V) in gamma iron. If this is quenched in salt water or other abrupt medium, it is called austenite, but if quenched in oil, probably martensite, which is a more stable form resulting from the austenite giving way along its cleavage planes. On heating or drawing martensite, there is a slight precipitation of ferrite or beta iron. This mixture consisting of beta iron and a solid solution of carbide in gamma iron is called troosite which becomes sorbite on further drawing or on a further precipitation of beta iron. At the  $A_c$  point the beta iron is converted into alpha iron and on the drawing being continued the gamma solution approaches the eutectic until at the  $A_c$  point it is converted into pearlite. The mixture now consists of ferrite and pearlite.

*Annealing.* The object of annealing is to relieve strains and to soften the structure or make it normal. It consists in raising the steel to a temperature above the  $A_c$  point and holding it a sufficient time to get a complete solid solution. Then allowing it to cool slowly in the furnace in order that all transformation may be completed—austenite, martensite, troosite, sorbite and ending with a mixture of ferrite and pearlite. This is a furnace or soft anneal.

Most annealing or better normalizing is done by merely heating past the  $A_c$  point and then cooling in air. This gives a mixture of ferrite and sorbite instead of ferrite and pearlite as results in furnace cooling. If a fine structure is wanted coincidentally in a good soft material, quench at above the  $A_c$  point and draw at just below the  $A_c$  point.

*Quenching.* Materials are quenched in order to get

maximum hardness and grain refinement. It consists in heating the steel past its  $A_c$  point and quenching in oil or water. This retains it in its austenitic and martensitic condition which is very hard and fine. See Fig. 2.

*Drawing.* Drawing consists in heating to some point below  $A_c$  and cooling in air or oil. This is a softening or toughening process in which ferrite is liberated varying with the increase of draw. Practically all of these steels on being drawn are sorbitic, as shown in Fig. 3.

*Grain Size.* Care should be exercised in not passing the upper critical too far, as the grain size grows accordingly and there is danger of overheating.

*Overheating.* This causes a very coarse structure but it can be restored by merely heating to a little above the critical (upper) point and quenching. Overheating should not be confounded with burning. Compare Figs. 4 and 5.

*Burning.* Burnt steel is brittle and its fracture is coarse and shiny. Material that has been burnt is of no value in this work.

*Test Specimens.* All specimens that are heat-treated for test purposes are carefully machined to the required shape and size, then treated in electric or oil furnaces. Much attention should be paid to the machining of specimens, as an extra deep cut will spoil the test. This often occurs near the shoulder. The data from a poor specimen are of no value.

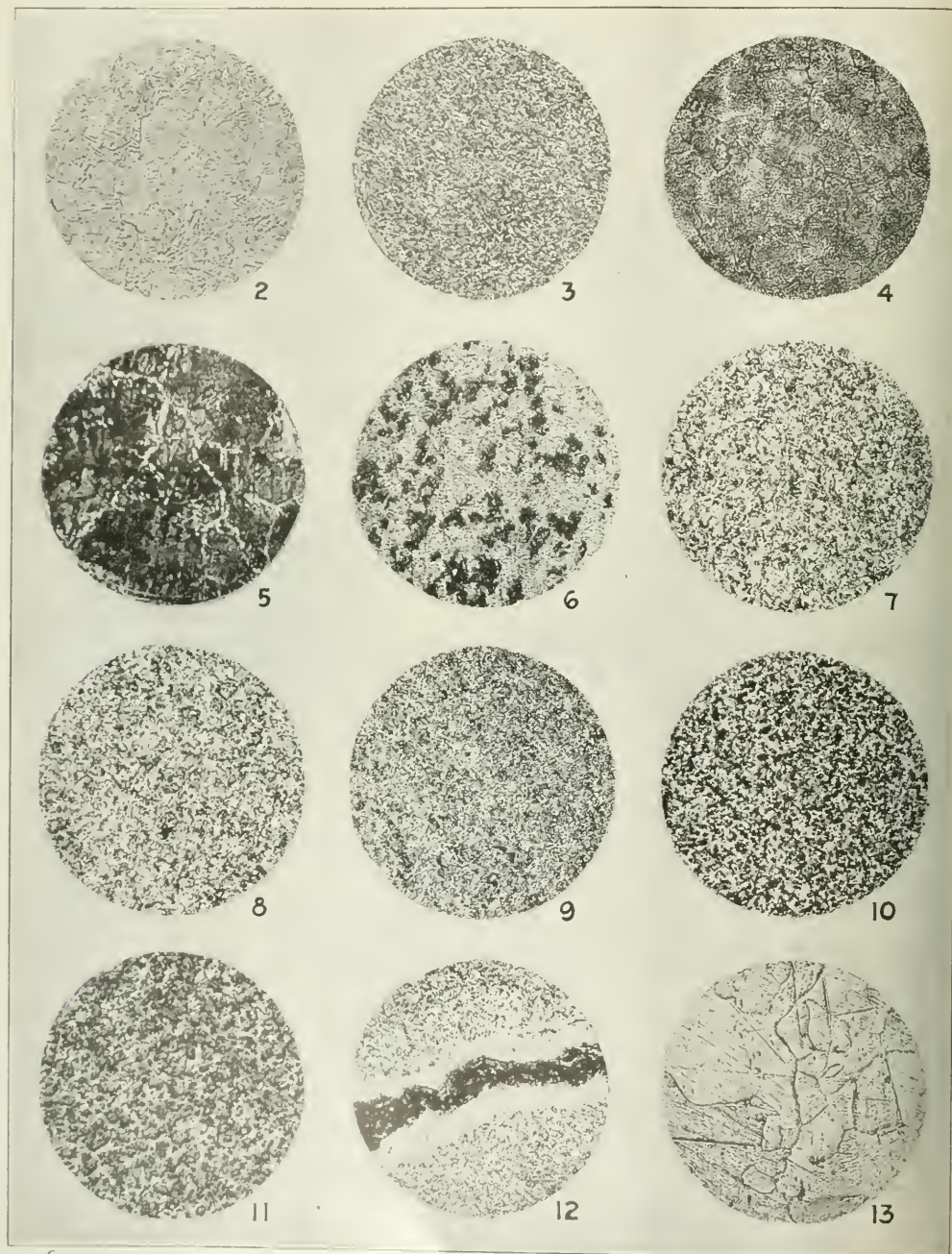
#### FURNACES AND PYROMETERS

*Electric Furnaces.* The electric furnaces used are of Hoskins manufacture and give a good even heat up to 2000 deg. F. They are especially adapted to heavy duty or continuous operation and are capable of 24-hour-per-day service. The heating units of chromel in the shape of hair pins can be easily removed and replaced in a short time in case they are burned through. They operate on low voltage (10 to 57.5 volts) for which reason they are best adapted for use on alternating-current circuits in connection with a transformer. It takes about two hours to reach 1800 deg. F. from a cold furnace. The thermocouple enters at the center of the rear. In order that the material treated may be nearer the couple, a piece of sheet steel or secondary bottom is inserted. This is placed on small supports of sufficient height to bring the sheet within a distance of two inches of the couple. This sheet will also prolong the life of the furnace lining.

The atmosphere is oxidizing, so that at high temperatures care must be exercised to prevent excessive scale. It is sometimes necessary to inclose the samples in boxes or tubes in which has been placed some oil, kerosene, etc. The covers are sealed with fire clay.

Where a specimen is to be quenched at say 1500 deg. F. the furnace is slowly brought up from 1000 deg. F. over a period of about 30 minutes to 1500 deg. F. At this point the temperature is held for 10 minutes to insure good results. The sample should be rapidly transferred to the quenching medium to prevent undue oxidation and decrease in temperature.

*Quenching Mediums.* Kerosene, fish oil, wool oil with a mineral oil base, warm water, salt water, soapy water, a layer of oil on water. The kerosene is used for high-speed tools, tungsten, etc.; fish oil or wool oil for prac-



1738, 2-13

Fig. 2—Effect of Quenching. Fig. 3—Effect of Drawing. Fig. 4—Effect of Overheating. Fig. 5—Effect of Burning. Figs. 6-11—Low Carbon Steel. Analysis: C, 0.26%; Mn, 0.30%; S, 0.006%; P, 0.015%. Etched with picric acid, x 100. Fig. 6, annealed; 7, quenched; 8, quenched and drawn at 1000 deg. C.; 9, quenched and drawn at 1000 deg. C.; 10, quenched and drawn at 1200 deg. C.; 11, raw stock. Fig. 12—Seam in Tubing, x 100. Fig. 13—Carbonized Area in Tubing; x 100.



tically all steels where toughness and hardness are needed; warm water for high carbon tools to prevent cracking; salt water to give extra hardness; soapy water for a less rigid quench than warm water; and oil on water to ease the rigid quench of the water.

*Drawing.* Heat the specimen slowly to the required temperature, hold for 30 minutes, varying time according to the size, shape, etc., of specimen; then remove and cool in still air. Do not lay on cold steel as there will be inequality of cooling.

*Oil Furnaces.* In most cases the time should be lengthened for holding the pieces to be heat-treated over that of the small electric furnaces. When the parts are inclosed in boxes it should take at least three to five hours to get the necessary results. The size of the material varies the time for holding, i.e., a small part takes less time than a large part. By careful manipulation a neutral and slightly reducing atmosphere can be maintained. Do not use too great excess air and keep the furnace doors closed as much as possible.

*Gas Furnaces.* Gas furnaces give excellent results for heat-treating. They are easy to adjust, and atmospheric conditions can be held either oxidizing or reducing which is a very important item. Every furnace should be cleaned out regularly. Oxide and other debris soon obstruct the flow of the heat and cause unequal heating; also in the case of gas, back-firing may result. In lighting a gas furnace open the door for a short time before tossing in a lighted piece of paper, then turn on the gas. Do not stand in front of the door when lighting.

*Pyrometers.* All heat-treating devices should be equipped with pyrometers. These must be checked regularly either by means of a standard pyrometer or constant melting-point materials. Care should be exercised in the method of placing the couple in the furnace or bath, for sometimes the heat registered is not the same as the heat at the point where the material is being heated. All couples should be inclosed in protecting tubes as they soon oxidize otherwise. The cold ends should be noticed to see that they are not unduly heated by the furnace. A good quick check on a pyrometer is to insert the couple in a molten bath of sodium chloride and plot the cooling curve.

LOW CARBON STEEL

Low carbon steel is used for tubing, sheet steel, armorizing, nuts and bolts.

*Tubing.* There are two kinds of tubing used, seamless and welded. It has an average chemical analysis of 0.15 per cent carbon, 0.35 manganese, 0.045 sulphur, 0.014 phosphorus; and the following physical properties when quenched at 1625-1650 deg. in oil and drawn at 1000 degrees:

|                        |                   |
|------------------------|-------------------|
| Ultimate strength..... | Pounds per sq.in. |
| Yield point.....       | 65,000            |
| Elongation.....        | 59,500            |

Tubing is oxidized very much on being heat-treated at this can be reduced to a minimum by placing the tubing in containers (larger tubing) and excluding the air; then using speed in transferring to the quenching medium. The temperature for normalizing this steel about 1650 degrees.

To determine whether the tubing is welded or seamless, a section about 1½ inches long is ground smooth

on each end and placed in a 20 per cent solution of H<sub>2</sub>SO<sub>4</sub> at a temperature of 150 deg. for 25 minutes. If welded it will show even without a microscope.

Defects often found in tubing are decarbonized spots or variations in carbon content from one end of a tube to the other, slag inclusions, seams, laps, etc. Fig. 12 shows a seam, the boundaries of which are decarbonized.

*Sheet Steel* has a composition of about 0.25 per cent carbon, 0.50 manganese, 0.045 phosphorus, 0.045 sulphur, and gives the following properties when quenched at 1600 deg. in oil and drawn at 1250 degrees:

|                        |                       |
|------------------------|-----------------------|
| Ultimate strength..... | 70,500 lb. per sq.in. |
| Yield point.....       | 60,250 lb. per sq.in. |
| Elongation.....        | 30 per cent.          |

Raw stock drawn at 1000 degrees:

|                        |                       |
|------------------------|-----------------------|
| Ultimate strength..... | 67,400 lb. per sq.in. |
| Yield point.....       | 59,700 lb. per sq.in. |
| Elongation.....        | 20 per cent.          |

The temperature for normalizing is 1575 to 1600 degrees.

Defects most often found are slag inclusions and laminated material. This laminated steel is caused from

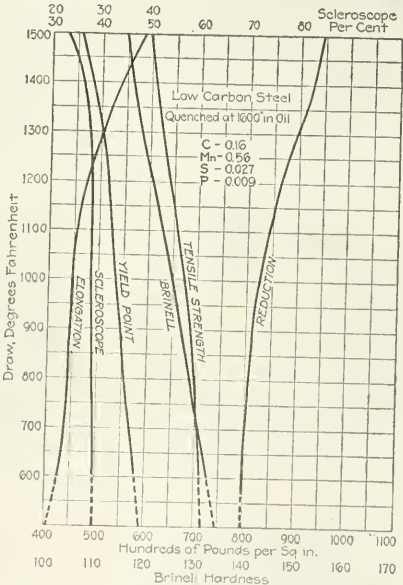
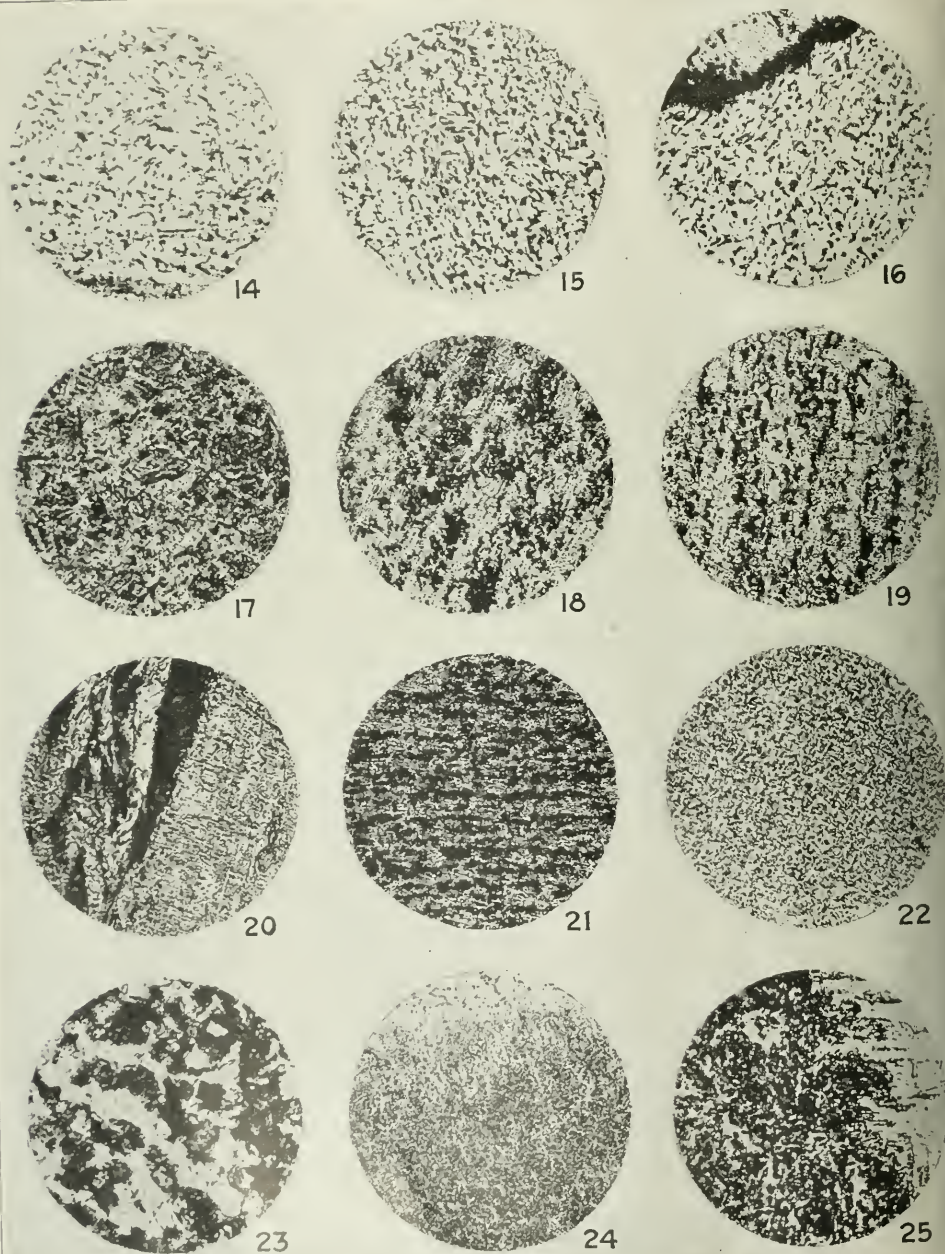


PLATE 1.—PROPERTIES OF LOW CARBON STEEL

cold rolling below the critical range, or sometimes by phosphorus which has expelled the carbon in slow cooling. It can be improved by long annealing at about 1650 deg. but hardly ever completely removed. Phosphorus occurs in solid solution in the ferrite. In crystallizing out, the phosphorus is maximum at the surface of each crystal. These crystals on being rolled form elongated masses or bands.

Tubing and sheet steel are made into many different parts. They should be annealed first or else there is danger of cracking and strains. After the material has been fabricated it is heat-treated by quenching in oil at about 1600-1625 deg. and drawing at from 900 deg. to 1100 deg., according to the strength wanted





FIGS. 14-25

Fig. 14—Section of ear No. 1 at fracture; x 100. Fig. 15—Same some distance from fracture; x 100. Fig. 16—Section of ear No. 2 at fracture. The structure some distance away was same as Fig. 15. Fig. 17—Section from ear No. 3 at fracture; x 100. Fig. 18—Same some distance from fracture; x 100. Fig. 19—Section of ear No. 1 after annealing; x 100. Fig. 20—x 100. Fig. 21—x 100. Fig. 22—General structure of the rim; x 100. Fig. 23—The same; x 400. Fig. 24—The weld; x 100. Fig. 25—The same; x 400.

In some cases normalizing is sufficient, that is, heating to 1575 deg. to 1625 deg. and then cooling in air.

In cleaning this material it is sometimes subjected to a pickling operation (immersing in dilute acid). Care should be exercised to prevent excessive action as the weakening effect is great. Much of this type stock is brazed or welded. Acids should not be used as flux and the steel should be in the annealed condition before the weld or braze is made. In heating, if the acetylene torch is used, a sufficient area should be heated to prevent cracks from expansion and contraction.

One case was found where aluminium had been used as a deoxidizer in the manufacture of the steel. It ( $Al_2O_3$ ) had segregated in a line of dots and on brazing, being a line of weakness, caused the failure of the steel.

**Carbonizing Steel** has an average analysis of 0.20 per cent carbon, 0.50 manganese, 0.06 sulphur, 0.045 phosphorus. When quenched at 1625 deg. and drawn at 900 deg. it has the following properties:

|                           |                        |
|---------------------------|------------------------|
| Ultimate tensile strength | 70,000 lb. per sq. in. |
| Yield point               | 51,000 lb. per sq. in. |
| Elongation                | 34 per cent.           |
| Reduction                 | 70 per cent.           |

In carbonizing, the part is left in the compound from six to twelve hours, according to the thickness of the case wanted, at a temperature of 1600 deg. to 1625 deg., then cooled in the boxes to room temperature.

This material is now quenched in oil from a temperature of 1600 deg. to 1625 deg., which gives a good tough core. A second quench is given at 1450 deg. to 1475 deg. in water, after which it is drawn at about 450 deg. to relieve any existing strains.

One lot of steel used for cam shafts because of open structure became brittle and showed tiny cracks after carbonizing. In order to get away from this condition the steel was first heat-treated and then carbonized.

It is not good practice to quench material direct from the boxes in water as the resulting structure is very coarse and brittle.

**In Nuts, Bolts and Screws** the phosphorus and sulphur sometimes run high, 0.10 per cent, in which case the nuts are brittle; also they show laminations. Nuts from this material can be improved by drawing at from 1000 deg. to 1150 deg. It is not advisable to use a high-sulphur high-phosphorus material, especially where they are under stress, as they are likely to fail suddenly, due to segregation of crystals. Of course, it makes a nut or a bolt that is very easy to machine and it will oft-times pass the physical tests without a special treatment, but it absolutely should not be used in this kind of work. The usual physical test is to compress the nuts 20 per cent of the shortest diameter of the nut.

All investigations indicate that low carbon steel causes more trouble than all of the other steels. Welded tubing is sometimes mixed with unwelded necessitating the sawing off of sections and treating them in dilute acid as spoken of before. Strain lines are set up by bending tubing without proper annealing and in the case of soldering, welding, and brazing, there are numerous illustrations of the tubing being burned. Too much emphasis can not be placed on the importance of properly neutralizing any remaining solution or salt used as a flux or cleaner. A soda wash after the

operation is very good for this. It is best to use a neutral flux such as borax, if possible. Brazed joints for tubing are superior to any other when properly heat treated as shown by conclusive data in chapter on brazing and welding. It is not necessary to heat any tubing to anywhere near a burning temperature to get perfect brazes.

The use of silver solder is not necessary unless on joints between copper and brass fittings. Ordinary brazing material has been used here successfully. Two important points in regard to silver solder are its great cost and its sluggishness in use.

Sheet steel and tubing should not be sand blasted before brazing as extra heat is necessary to get the brazing material to flow. This extra heat causes rejections from burning and splitting.

Quantities of laminated sheet steel are spoiled by sending to the punch presses to be fabricated into parts before being properly annealed or normalized.

There is always considerable scale formed in heat-treating steel. This is very objectionable as it necessitates the steel being carefully cleaned; also there is considerable reduction in size.

By immersing the steel in a dilute solution of hydrochloric acid, about 6 to 10 per cent, and then treating, we get a good, clean, smooth, bright surface. This is very important as there is a large labor saving and the steel is more desirable in many ways.

Many test pieces tried out after immersing and heat treating showed the same strength as other pieces quenched or annealed at the same temperature but not subjected to acid. The decrease in diameter of the part was very slight. In the case of bar stock it was about 0.0006 inch and the surface remaining was perfectly bright. This practice is certainly worth trying especially in annealing or quenching sheet-steel where the oxide formed without the immersing in the acid solution is very objectionable.

#### STEEL TUBING INVESTIGATION

This material on being inspected showed a peculiar streak about one-half inch wide extending the entire length of the tube. A section was taken from the streak, polished, etched with picric acid and photographed at a magnification of 100.

Fig. 13 shows that the streak along the tube was a decarburized area probably caused by the tube coming in contact with some oxidizing agent (flame). This causes a line of weakness, necessitating rejection.

#### AEROPLANE FITTING INVESTIGATION

Three metal ears from certain aeroplane fittings, being fractured, are investigated to discover the source of the fracture. They were made from ordinary sheet steel. Sections from each of the ears were taken near the fracture and at the opposite side; also ear No. 1 was given a long anneal at 1650 deg. and then a section was taken. These sections were polished, etched with picric acid and photographed at a magnification of 100. The results are shown in Figs. 14 to 19 inclusive.

**Summary.** Ears 1 and 2 have a very laminated structure. The crystals were distorted by cold-working resulting in decreased ductility and increased brittleness. Strain lines would certainly be set up in bending such material, which would become enlarged by vibra-



tion. Ear 3 has a much better or softer structure than 1 and 2. It should bend easily and without the strain lines. Near the point of fracture it appears to have been bent several times before failing.

Ear No. 1, after annealing, showed as Fig. 19. This indicates that the material showing laminations as ear 1 and 2 should be given heat treatment before placing in the machine. Would suggest annealing at 1625 deg. first and then after the part is made a heat treatment of 1625 deg.; quench in oil and draw at about 100 deg. Fahrenheit.

#### INVESTIGATION OF TERNE PLATE

Terne plate showing raised spots or bubbles was investigated to see if the places were in the steel or between the steel and plating. Sections were taken, polished, etched with picric acid and photographed at a magnification of 100. Fig. 20 shows that the bubble or gas cavity was in the steel itself. There have been instances where the bubbles were under the plating and not in the steel.

#### STIRRUP INVESTIGATIONS

This stirrup (212100) showed lines on the side. These were investigated in order to determine their depth and to see if the material was distorted by any strain. Sections were taken from the place showing the lines. The sections were polished and examined and then etched with picric acid and photographed at a magnification of 100.

**Summary.** The scratches proved to be surface (die pinching) defects and had practically no depth. As shown in Fig. 21, the material is badly laminated due to rolling or excessive phosphorus. The scratches investigated are insignificant and if they are in the other parts as the one submitted will cause no damage.

The object of another stirrup investigation was to investigate the strength of the materials. The stirrups showed marks on the side that looked like cracks or strains. A part showing the marks was sectioned in two places, one showing the marks (this was heated to about 1300 deg. and straightened), and one some distance away without marks. These parts were pulled on the machines and showed as follows:

Sections heated and straightened:

A—71,500 lb. per square inch  
B—72,000 lb. per square inch

Section as the material was:

A—70,500 lb. per square inch  
B—68,500 lb. per square inch

**Summary.** This report checks out the photomicrographs in that the strength of the material is all right and the marks are surface marks only.

#### WHEEL RIM WELD

**Wheel Rim Investigation.** The object of this investigation was to contrast the structure of the steel at the weld and other places in the rim. Sections were taken, polished, etched with  $\text{HNO}_3$  solution (10 cc. in 90 cc.  $\text{C}_2\text{H}_5\text{OH}$ ) and then photographed. The results are shown in Figs. 22 to 25 inclusive.

**Summary.** The steel near the weld has its carbon content increased, probably due to the fact that a reducing flame was used in the process of welding. By a reducing flame is meant a flame with excess CO. There

should be sufficient oxygen to cause the complete reaction  $2\text{CO} + \text{O}_2 \rightarrow 2\text{CO}_2$ . A yellow flame indicates a reducing condition; but care should be taken not to confound this flame with a yellow flame caused by any soda in the air ( $\text{Na}_2\text{B}_2\text{O}_7$ ).

(To be Continued)

### Ownership of Chemical Concerns Probed by Alien Property Custodian

On the contention that the transfers of stock made just prior to the entrance of the United States into the war were not *bona fide*, the Alien Property Custodian has undertaken a searching inquiry into the ownership of Roessler & Hasslacher Chemical Co., New York; Niagara Electro-Chemical Co., Niagara Falls; and Perth Amboy Chemical Co., Perth Amboy, N. J.

According to the testimony of Wm. A. Hamann, treasurer of Roessler & Hasslacher, the stock in the three concerns was sold by Germans to American interests just before the entrance of the United States into the war because of a threatened power shortage at Niagara Falls and because of new processes being developed in this country which would be dangerously competitive.

Joseph H. Choate, conducting the inquiry for the Alien Property Custodian, questioned the good faith of the transfer and introduced a cablegram from Dr. Roessler stating that a decision could not be reached "without knowing your real intention; and whether real business or formality only is meant." The cablegram also suggested sending a "confidential man" to Germany to negotiate for the transfer of the stock, which was done last January.

The close relationship of the three firms with a group of German industrialists was shown by the testimony of Franz Roessler, vice-president of the Roessler & Hasslacher Company. His father, Friedrich Roessler was the founder of the Gold and Silver Scheide-Anstalt at Frankfort which, until the alleged transfer of stock, owned the major interest in the Roessler & Hasslacher Chemical Co., the Niagara Electro-Chemical Co., and the Perth Amboy Chemical Co. In examining Franz Roessler, it was brought out by Mr. Choate that the relationship between the owners of the German and American organizations was so intimate that the transfer of stock worth millions was made without the formality of signing papers or transferring funds.

Mr. Roessler stated that the transfer was made on the basis of \$200 a share for Roessler & Hasslacher, \$400 for Niagara Electro-Chemical, and \$200 for Perth Amboy Chemical stock. Counsel for the Alien Property Custodian pointed out that this was a low figure, considering that the Niagara Company had paid dividends as high as 1100 per cent and the other two companies as high as 100 per cent each. To this Mr. Roessler replied that the pending break between Germany and America made the German owners anxious to dispose of their stock on the best terms they could get.

The quantity of limestone sold in the Bowling Green district, Warren County, Ky., in 1917, for use in building operations, according to reported sales of four companies, decreased by 55,126 cubic feet, valued at \$12,421 from that of 1916.



4. **The Inspiration Machine.** In construction this machine is extremely simple, while in principle it shows one difference from the Callow machine, viz., that instead of splitting the pulp between a great number of

cells it is forced to travel through a series of compartments in succession. This same policy has been followed in the construction of the Minerals Separation machine.

Fig. 4 shows an Inspiration flotation machine of steel construction. The machine is divided into two compartments, A and B, each 24 feet by 8 feet 6 inches. Each compartment in turn is subdivided into eight sections, each 3 feet long. Between the compartments A and B is placed an overflow gate G which regulates the height of pulp in the minor sections of A, while the end

pan with longitudinal riffles, which riffles are cored as shown in section E-E for the interchange of air between the narrow channels thus formed. A steel spider G, Fig. 11, which forms the upper part of the porous bottom, is fastened to the lower part G' by a number of bolts around the edges. Before putting them together a porous medium (canvas) is placed between the two pieces. The air enters through a pipe P from the top which screws into the lower casting; arrangements are made, of course, to secure an air-tight joint J where the air passes through the porous medium.

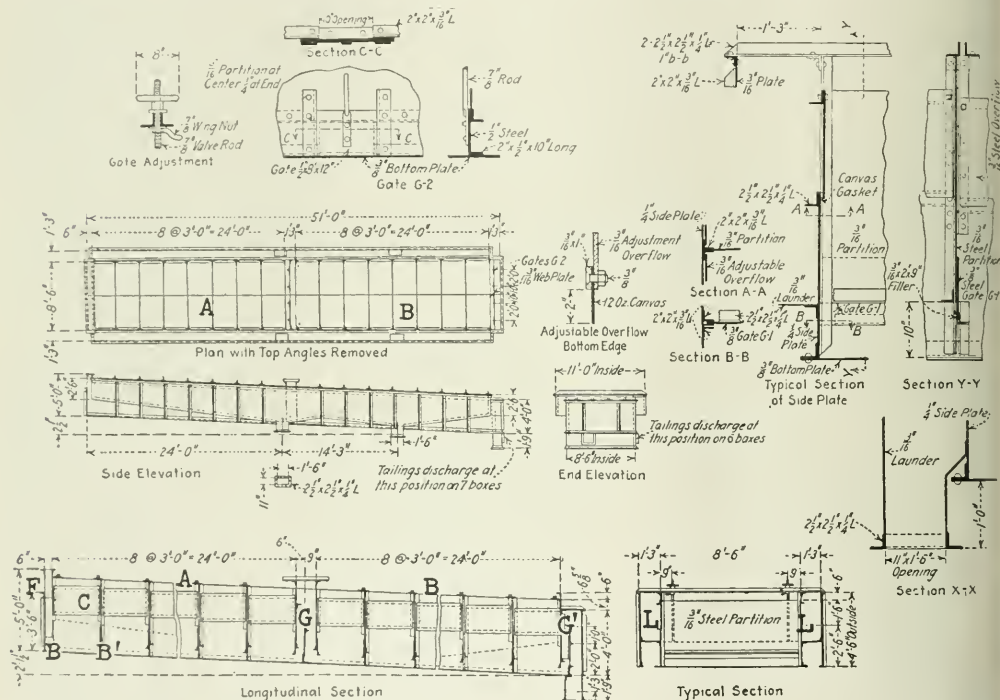


FIG. 10—INSPIRATION FLOTATION ROUGHER CELL

of the second compartments is another overflow gate G' which controls the pulp-level in the sections of compartment B.

The feed enters the machine at F, passes under a baffle B and into the first section or cell C, where a froth is formed which overflows into the launders L on either side of the machine and running the entire length. The tails from this first section pass under the baffle B into the second section or cell where further froth is formed, continuing in this way through the entire length of the machine. The subdivision into two compartments is in the interest of closer regulation of the pulp-level.

In the Inspiration machine the bottom plates are all solid; all pipe connections are made from above and are at all times visible. The porous bottoms rest on top of the regular bottom of the machine and air is introduced from the top. Their construction is illustrated in Fig. 11, and consists of a shallow cast-iron

When assembled, the bars of the upper grate form channels in the lengthwise direction of the machine. These bars are the only part that protrude above the canvas, and, on account of their longitudinal arrangement, do not interfere with the passage of pulp through the machine.

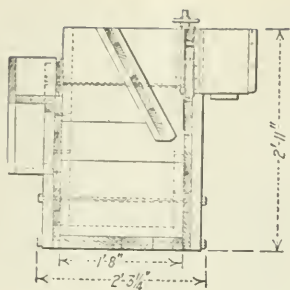
**5. The Launder Machine.** This apparatus<sup>14</sup> is similar to the Callow cell, making use of air under pressure forced through canvas or some other porous medium. In this machine the air distributor is loose and is lowered from the top of the cell. With this arrangement it is evident that a distributor can be removed for repairs without interrupting the operation of the machine.

It will be seen from Fig. 12 that the machine is quite simple in construction, being merely a vat divided into six sections, the pulp flowing through a by-pass B from one cell to the other. A drop of 3 inches from

<sup>14</sup>B. M. Snider, Min. & Sci. Pr. Aug. 11, 1917.







the Central Mine, Broken Hill, Australia.

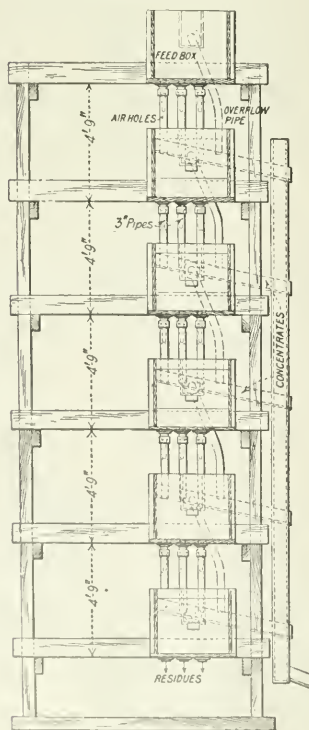
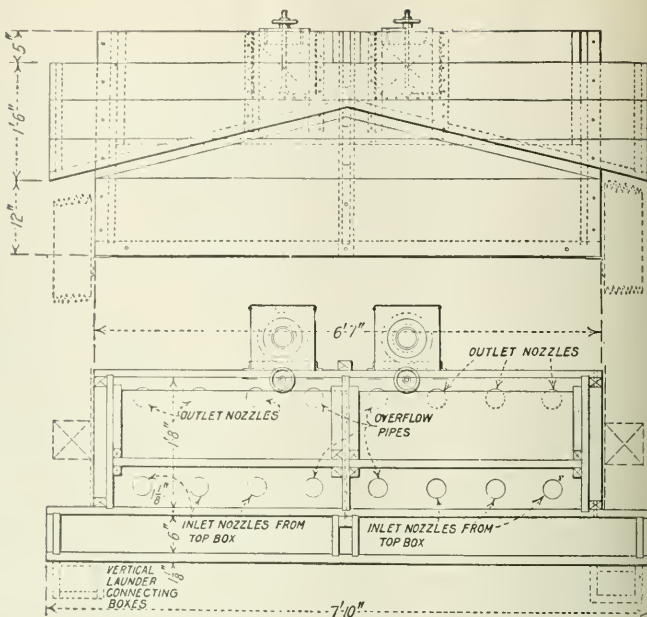
#### COMPARISON OF THE OPERATION OF THE DIFFERENT CLASSES

The object and purpose of all flotation machines in practice is to form a froth of mineral collector which, of course, is composed of air bubbles. Each bubble is loaded with mineral particles which it has picked up during its passage up through the pulp. These bubbles accumulate on the surface and are skimmed off or allowed to overflow by gravity.

In Class I, the pulp of proper consistency together with the proper amount of frothing agent passes into an agitating chamber where it is thoroughly emulsified and aerated. From this compartment it flows through an opening into a spitzkasten or settling compartment where the bubbles which have been beaten into the pulp collect mineral particles, drag them to the top to a tough and persistent froth which is skimmed off, broken up by some means, dewatered and dried as far as possible.

In Class II, 1 and 2, the pulp in an agitating compartment receives less violent mechanical agitation than in Class I. The aëration is aided by the injection of air into the pulp, thus relieving the impeller of part of its duty. Class II, 2, has a porous medium at the bottom of the settling compartment through which air is forced. This aids the bubbles formed by mechanical agitation to carry their load of mineral particles to the surface, where they are skimmed off.

In Class III the ore, water, oil and other reagents in an emulsified condition are subjected to the action of a bubble column. Air is forced through a porous medium of some kind, located at the bottom of the cell, circular or rectangular, but generally of the latter form. These bubbles are very small and proceed to pass up through the



Section A-A

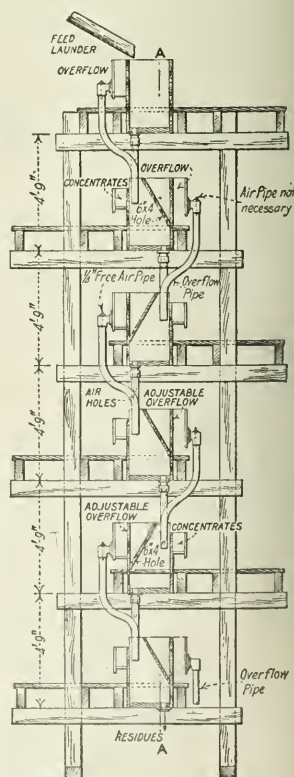


FIG. 13. A CASCADE MACHINE TRIED IN AUSTRALIA

pulp one after the other. During the early part of their trip they are coated with an exceedingly thin film of oil. In this condition they are capable of collecting mineral particles (generally sulphides), which are also oiled, carrying them to the surface forming a concentrate froth.

In comparing the machines of each class it will be seen that the only real difference in mechanical frothing machines is mechanical, the underlying principle is the same. The main point of difference between the Minerals Separation machine and the Janney is in the method of driving the impeller, the latter having an individual-motor-driven impeller. Other small differences, of course, exist in mechanical details of the two machines.

Turning to the pneumatic class of flotation machine, the Callow machine differs from others in two main respects, viz., in its pulp-level control device and in its sloping bottom. A uniform pulp-level in the Callow cell is maintained by a float and plug-valve, while in nearly all other machines of this class the constant pulp-level is maintained by an overflow gate or goose neck. The sloping bottom of the Callow cell calls for some means of giving a uniform discharge of air throughout the length of the cell under a varying hydraulic head. This is accomplished by dividing the porous medium into a number of sections each having an individual valve. Other pneumatic machines have a nearly level bottom over which the hydraulic head is constant. The Callow cells also are long and quite narrow, and the feed is split to several of them, while others, excepting the launder machine, are short and wide (taking the length in the direction of the flow of the pulp).

There is a tendency in machines of late design to lower the porous bottoms from the top of the cells, and to make all adjustments in their operation from above. This is the logical place to make the adjustments since any irregularity in the operation of the machine can be noticed while the adjustment is being made. Also any cell in the series can generally be cut out without hindering the operation of the remaining ones, excepting that they are momentarily overloaded.

#### FROTHS FORMED BY MECHANICAL AND PNEUMATIC MACHINES

One thing is sure—air bubbles produce the froths in both mechanical and pneumatic systems and often the same quantities of oil are used in pulps made up with the same quantities of water. Yet the pneumatic froth dies as soon as the supply of air is cut off, while the mechanical froth does not break down for a considerable length of time—occasionally weeks. When the machines are running the froths appear very much alike, except that the froth on the pneumatic machines appears whiter and does not seem to contain as much mineral.

As far as can be learned the difference between the two froths lies largely in the different percentages of air and moisture as compared with the amount of solids. The continual supply of air by the pneumatic method produces a condition under which each rising bubble carries only a few grains of mineral, whereas in the mechanical methods the bubbles come up fairly heavily laden.

The agitation in the pneumatic method, due to the

uprising and bursting bubbles, does not afford the ideal condition to form a froth of strength. The relatively quiet spitzkasten of the mechanical machine allows the bubbles to become loaded to capacity, and this seems to toughen the froth. O. C. Ralston<sup>1</sup> states that it may rightly be called a "mineral mud." If a pneumatic machine is allowed to run for some time with no removal of froth the layer of froth on the top finally becomes similarly loaded, although the continual rush of large volumes of air through this layer keeps it more or less fluffy and wetter than a mechanical froth.

In conclusion it may be stated that the only difference in the froths produced by the two classes of machines is in the amount of water and air present for a given weight of mineral supported.

#### METALLURGICAL AND ECONOMICAL DIFFERENCES OF MECHANICAL AND PNEUMATIC MACHINES

Regarding this question Mr. O. C. Ralston makes the following statements:<sup>2</sup> "The two methods of flotation give nearly the same metallurgical results. However, comparisons made in a number of competitive tests indicate that the mechanical machines give a somewhat better extraction on coarse particles of minerals, and that the pneumatic machines make a better separation on the finer slimes—provided the oil has been well mixed with the pulp. With the same pulp the pneumatic machines give a very slightly better total extraction than the mechanical machines.

In practice the machine that gives the highest total extraction is usually considered the best. This is especially true in copper mills. In zinc mills the highest possible grade of concentrate is of importance and should be considered. Pneumatic machines require slightly less power and less labor.

#### POROUS BOTTOMS

It will be recalled that in most flotation machines canvas is the medium through which air is forced in order to give the necessary fine division. In the Flinn-Towne cell carborundum is used and is said by some not to give satisfaction on account of the clogging of the pores. Canvas may also be used in this machine.

Some experiments<sup>3</sup> with porous mediums have been made by the Inspiration engineers. Rubber sheets perforated with a multitude of needle holes have given good results; their life is quite limited, however. Sponge rubber has also been tried, but without lastingly good results. The advantage of rubber should be, in the first place, its smoothness. It would have less tendency than canvas to permit the formation of incrustations. Besides, an elastic medium should have the additional advantage of avoiding the danger of catching small sand particles in the pores of the medium.

Canvas, four ply, stitched every half inch, is considered the standard medium.

A normal capacity for a standard roughing cell of the Callow type is 50 tons per 24 hours, but varies according to the nature of the ore. At the Inspiration mill, where flotation is practiced as the prime process,

<sup>1</sup>"Answers to Questions on the Flotation of Ores," by O. C. Ralston. *Technical Paper*, 149.

<sup>2</sup>Ibid.

<sup>3</sup>"Notes on Flotation," by J. M. Callow, *Bull. A. I. M. E.* Dec. 1915. *Eng. & Min. Jour.*, Dec. 4, 1915. *Mer. Min. Jour.*, Dec. 15, 1916. *Met. & Chem. Engrg.*, Sept. 1, 1915.

each 1000-ton section employs 24 roughing cells and 4 cleaners in series, an average of 33.3 tons per roughing cell is made. At other plants a capacity of from 35 to 65 tons per cell is made.

The Inspiration standard duplex machine consists of 16 double roughing compartments 3 feet by 3 feet 4 inches and a cleaner cell of 6 double compartments 3 feet by 3 feet, treats 800 tons per day, giving a tonnage of 1.62 tons per square foot per day for a total combined area of rougher and cleaner of 492 square feet. These machines, as others, are capable of carrying a 100 per cent overload for short periods of time without much loss in the tailings.

The Kollberg and Kraut flotation machine, as recorded at the Burro Mountain Concentrator, treats 75 tons of dry feed per day per cell. The manufacturers claim for it a capacity of from 80 to 150 tons per day.

The Cole-Bergman flotation machine is designed to handle large tonnages and, according to Mr. David Cole, will handle twice that of the Callow cell for the same floor space. The three-stage machine shown in Fig. 9 will handle up to 400 tons per day.

The Flinn-Towne Cell, on account of its cylindrical shape, is not adaptable where large capacities are required. The cell shown is designed to treat 40 tons per 24 hours.

A bank of Minerals Separation machines, containing 15 agitators each, 3 feet square, and 14 spitzkastens, handles about 400 tons of sand or 175 tons of slime per day.\*

Janney mechanical machines installed in a row of from 5 to 15 cells will treat from 100 to 500 tons per row.

Janney mechanical-air cells installed in a series of one mixer and 5 flotation cells will treat 200 to 250 tons per day of 24 hours.

#### AIR AND POWER CONSUMPTION

The air consumption per square foot of the Inspiration machine is about 11.8 cubic feet per minute at a maximum pressure of 4½ pounds. The actual power consumed is 2.63 kilowatt-hour per ton of ore treated. Callow cells at the National Copper Company, using approximately 950 cubic feet of air at 4 pounds pressure, and treating 500 tons per day on 8 roughers and 2 cleaners, require 3.5 hp. per cell or 1.25 kilowatt-hour per ton.

A Minerals Separation mechanical agitation machine, with 15 agitator compartments 2 feet square and 14 spitzkastens, as installed at Anaconda, required 45 to 55 hp. under full load.

For each Janney cell about 150 cubic feet of air per minute at 4 to 5 pounds pressure is required.

The Janney mechanical cell has a 10-hp. motor installed over each, while 8 hp. is required to operate it.

The following table of power used by machines gives an interesting comparison:

| Machine                          | Kilowatt-Hours per<br>Ton of Solids |
|----------------------------------|-------------------------------------|
| Janney (with air baskets)        | 4 to 6                              |
| Minerals separation, mechanical  | 4 to 5                              |
| Minerals separation, submergence | 3.5                                 |
| Pneumatic                        | 3                                   |
| K. & K. (claim in catalogue)     | 2                                   |

These are of illustrative value only.

#### COST OF FLOTATION MACHINES

The cost of flotation machines is usually the smallest item in the cost of a plant, especially when compared with that of crushing machinery, filters, housing, etc.

The following summarized table of a number of installations has been reduced to unit figures and is of interest in comparing pneumatic and mechanical machines:

#### MECHANICAL FROTHING MACHINES

| Capacity, Tons per Day | Cost per Ton of<br>Daily Capacity |
|------------------------|-----------------------------------|
| 25                     | \$30 to \$50                      |
| 50                     | 25 to 45                          |
| 100                    | 20 to 40                          |
| 250                    | 15 to 35                          |
| 1000                   | 12 to 25                          |

#### PNEUMATIC FROTHING MACHINES

| Capacity, Tons per Day | Cost per Ton of<br>Daily Capacity |
|------------------------|-----------------------------------|
| 25                     | 25 to 40                          |
| 50                     | 12 to 20                          |
| 100                    | 8 to 12                           |
| 250                    | 6 to 8                            |
| 5000                   | 4 to 6                            |

The wide variation in these costs is due to differences in the machines used and the ores treated. The figures, however, serve to illustrate what can be expected.

Texas School of Mines,  
El Paso, Texas

#### Skilled Enlisted Men to Be Returned to Industries by the War Department

In response to appeals from all over the country, the War Department has decided upon a policy which will permit the return to necessary industries of highly skilled men taken from such industries, under a system of furlough which will be automatic, and which will not in the future as in the past leave to the discretion of company and other subordinate commanders the question of whether such furloughs shall be granted. Thousands of applications for such furloughs are now being sent out of Washington by various branches of the War Department, in response to the appeals of manufacturers and other producers of war material whose draftsmen, mechanics and other employees, engaged in the past and now upon Government orders for war work, have been taken from them by operation of the draft.

The adoption of the new policy means that enlisted men are to be returned to industry only in cases where the drafted man's employer is willing to swear that the man is badly needed and that no one can take his place. The Government department for which the manufacturer or other employer is working will, upon application, send a blank form to the employer, which he must fill out, swear to before a notary, and have signed by a government inspector who is conversant with the facts. The signed application then goes to the Adjutant General's office, with request from the interested Government department that the man wanted be granted an indefinite furlough, without pay, with the promise that after the need for the man's service has passed he will be returned to the Army and the Government notified.

While such men are on furlough they are not to be allowed to wear the uniform. The company employing such men must furnish the Government each month a report that such men are still in employment and the class of work engaged in. In case such men leave their employment, the employers must immediately notify the Government.

\*"Flotation Concentrator at Anaconda." *Bull. A. I. M. E.*, Mar., 1916.



# Aluminium and Its Light Alloys

Light Alloys of Aluminium Just Developing as Important Materials of Construction, Especially in Motor and Aircraft Industries—Discussion of Chemical and Physical Properties of the Element

By PAUL D. MERICA\*

**P**ROBABLY no metal has experienced the rapid development of its manufacture and scope of application that aluminium has within the past 30 years. A curiosity 60 years ago, it has become almost a household and industrial necessity today, and the growth of its use and application has not yet ceased. The motor and particularly the aircraft industries, today, are demanding materials for construction that are strong and light. If the development of the use of the metal, aluminium, lies mainly in the past, that of the development of its light alloys is really just beginning, and the future conceals, without a doubt, most important discoveries concerning the properties and uses of these alloys.

During the past few years the metal and its alloys have been the subject of much investigation and study, the results of which are scattered throughout the technical literature at least of six languages and eight countries. The author has considered that a brief, comprehensive resumé of what is known about this extraordinary metal may be of value to the multitude of those who are today manufacturing, selling, buying or using it in any of its many forms, and who otherwise may not have access to the information relative to the characteristics of the metal.

The data and information have been put in the form of tables and curves; the curves have been reproduced in such dimensions that accurate interpolation of values on them is possible by the use of a rule graduated in decimal parts of a centimeter. The probable degree of accuracy of data is indicated, or implied, by the number of significant figures in the values given.

## I. COMMERCIAL ALUMINIUM.

The metal, aluminium, is produced by the electrolysis of a bath of molten bauxite and cryolite in carbon lined pots. Owing to the impurities in the materials used, the metal thus obtained is itself not pure but contains small and equal amounts of both iron and silicon.

There are two well recognized grades of ingot aluminium on the market:

Grade 1 containing 99 per cent or more aluminium.

Grade 2 containing 98 per cent to 99 per cent aluminium.

These are furnished in ingot form and in the form of slabs or billets for rolling.

The Aluminium Co. of America is the sole producer in this country of metallic aluminium; there are, however, a number of firms which manufacture the metal or its alloys.

The story of the uses and applications of aluminium

is a quite long one. As might be expected it has made a place for itself everywhere where lightness, malleability, high electrical conductivity, and moderate resistance to corrosion are service features.

About one-third of the production is consumed in the automobile industry (Richards, 39), where it is used in the form of castings and sheet for chassis and panelling. Other major uses of this metal are for cooking utensils and vessels of all kinds, for electrical conductor to replace copper and in the form of alloy castings. It is also used as a deoxidizing agent in the manufacture of iron and steel, in the Goldschmidt Thermit process, as a substitute for stone in lithographic work, as wrapping foil, as paint powder, as a constituent of the explosive ammonal, as the anode in electrolytic rectification cells; it is manufactured in every commercial form; bars, tubes, sheets, powder, foil, sections, and ingots. Richards (45) lists about 200 commercial and technical uses of aluminium.

It may be worth while to point out that aluminium may be used as a substitute in many cases for metals which are either more expensive or are difficult or impossible to obtain. During the present shortage of tin aluminium foil can be used to replace tin and tin-lead alloy foil; it can be used at least for many cases as a constituent of bronze castings to replace tin. The greater cost per pound of aluminium than metals such as lead and zinc should not be allowed to give a false impression of its cost. In many cases, such as that of foil, of small manufactured articles, and of many castings, the size and shape of the article is determined by its use, so that it is the cost per unit of volume of the material, not that per unit of weight which must be considered. Aluminium compares quite favorably in this respect with other metals as the following table indicates.

| Metal          | Cost per Unit of Weight, per Lb. | Cost per Unit of Volume, per Cu.In. |
|----------------|----------------------------------|-------------------------------------|
| Copper.....    | 15c.                             | 4.8c.                               |
| Tin.....       | 38c.                             | 10.0c.                              |
| Lead.....      | 4c.                              | 1.6c.                               |
| Zinc.....      | 91c.                             | 1.4c.                               |
| Aluminium..... | 23c.                             | 2.2c.                               |

## II. METALLOGRAPHY OF ALUMINIUM.

Aluminium undergoes no thermal or other transformation in the solid state. Its microstructure is quite simple; the metal consists of grains or crystals within which are formed "rests" of the iron-aluminium compound, FeAl<sub>3</sub>, and of silicon. The microstructure is shown in figures 1 to 4. These impurities undoubtedly have a considerable effect on the properties of the metal and even on those of its light alloys.

## III. CHEMICAL PROPERTIES.

Aluminium is a very active element and under proper conditions reacts readily with other elements and substances such as chlorine, sulphur, oxygen. Its molecu-

\*Bureau of Standards; a more comprehensive treatment of this subject will be given in a forthcoming circular of the Bureau of Standards. Numbers in parenthesis following authors' names refer to a bibliography which will be published at the end of this series of articles.

lar heat of combustion is ( $\text{Al}_2\text{O}_3 = 102.2$  grams) 392,600 calories.

The ease, however, with which aluminium reacts with oxygen, water, etc., is very dependent upon the physical state of the metal. As a powder or in an amalgam for example it reacts quite readily with air, water and other substances as one would expect from its high heat of reaction. As a solid mass, however, its rate of reaction with the same substances is very much slower, often almost unnoticeable; this in many cases, as for example its behavior towards oxidation, is undoubtedly due to its protection by a thin coating of reaction product, be it oxide, hydrate or otherwise. An important corollary of this fact is that the rate of corrosion of aluminium and of its light alloys depends on whether this protective coating of oxide once formed remains in place, protecting the remainder of the metal, or whether it is removed as it is formed. Thus the corrosion of the metal and its alloys is much more rapid in running water, and under conditions in which air and water erosion also play a part than in still water.

Aluminium in the solid form is corroded slowly and superficially only by pure water. In the air, damp or dry, it is also only superficially oxidized. When heated to  $400^\circ\text{C}$ . for 10 minutes in air a beginning oxidation is noticed which increases slowly up to  $800^\circ\text{C}$ . and then increases rapidly. Very finely divided aluminium, wire or foil, will decompose water very slowly but noticeably at  $100^\circ\text{C}$ .

Ammonium hydroxide attacks aluminium slowly, forming aluminium hydrate; sodium and potassium hydroxides ( $\text{NaOH}$  and  $\text{KOH}$ ) attack it quite rapidly.

Sulphur, free or dissolved in carbon disulphide ( $\text{CS}_2$ ), does not affect aluminium at ordinary temperatures.

A solution of mercury salt attacks aluminium, the mercury liberated by the reduction of the salt amalgamates the aluminium. The aluminium in this amalgam is very active and from it aluminium oxide is very rapidly formed by the action of water. Aluminium articles must therefore be protected from the action of mercury salts.

Cold concentrated or dilute nitric acid ( $\text{HNO}_3$ ) attacks aluminium only very slowly; the metal becomes "passive" under the action of this acid. Dilute and concentrated sulphuric acid ( $\text{H}_2\text{SO}_4$ ) attack aluminium but slowly when cold. When concentrated sulphuric acid is heated with aluminium the latter is attacked with formation of sulphur dioxide ( $\text{SO}_2$ ). Dilute and concentrated hydrochloric acid ( $\text{HCl}$ ) readily dissolve aluminium, as well as other mineral acids in the presence of metal chlorides.

Seligman and Williams (99, 100, 102) have carried out extensive tests of the resistance of aluminium to corrosion by acids, particularly nitric, sulphuric and acetic acids, the results of which are of the greatest practical value in view of the extensive use of aluminium for kitchen utensils and for acid vats and condensers. Their conclusions follow:

The rate of attack of aluminium by cold acetic acid is small; it increases with increasing dilution of the acid. Aluminium vessels can be used for containing concentrated nitric acid, when cold; with hot nitric acid of any concentration aluminium has but a limited life. Dilute, cold nitric acid also can be handled in aluminium vessels,

but the life of the latter is not as long as with the concentrated acid.

The corrosion of aluminium is greater in mixed sulphuric and nitric acids than in either alone (contrary to previously held opinion), and aluminium vessels should be used only with caution for handling such mixed acids.

The presence of impurities, iron, silicon and copper is of little influence on the corrosion in acids; the presence of copper is much more injurious when the corrosion is by dilute acids than when by concentrated acids.

## 1. CORROSION

Our detailed knowledge of the corrosion of aluminium is perhaps largely due to Heyn and Bauer (130) who in a very thorough investigation described the characteristic variations in the behavior of aluminium to corrosion in water or air and studied the effect of different conditions upon this corrosion. Their investigation was made following an extensive epidemic of disintegration of aluminium cooking utensils which were then being put on the market. Upon storing, many of these became exfoliated, cracked and blistered, undergoing in many cases an almost complete disintegration.

Heyn and Bauer found that aluminium undergoes two types of corrosion; it may corrode uniformly, a coating of oxide being formed over the whole surface, or it may be attacked locally, with formation of blisters and exfoliation. The latter type of corrosion is of course most dangerous and destructive; it appears to occur only when the aluminium is in the hard or cold worked condition and with certain types of tap water or salt solutions. Calcium salts seem to be accelerators of this type of corrosion. Tap water for example produces only slight uniform corrosion after several months on soft or annealed sheet; whereas it causes local corrosion, blistering and disintegration with hard sheet. Distilled water and many other salt solutions on the other hand will not cause blistering even with hard sheet. Heyn and Bauer suggest that cooking utensils might well be annealed in order to eliminate entirely the danger of local corrosion.

This distinctive type of local corrosion is probably due (1) to the presence of initial stresses in the hard sheet which cause strains and buckling when released by corrosion and (2) the fact that as Heyn has shown "hard" aluminium is electropositive to soft or annealed aluminium (by about 0.03 volts in tap water).

An idea of the extent of corrosion undergone by aluminium may be gained from the following tables taken from Heyn and Bauer's results:

In distilled water, with access of air, the diminution in thickness of the sheets (from 0.8 to 1.2 mm. thick) in 207 days was:

|                         |            |
|-------------------------|------------|
| for "hard" sheet.....   | 0.0045 mm. |
| for "medium" sheet..... | 0.0048 mm. |
| for "soft" sheet.....   | 0.0054 mm. |

Samples of "medium hard" sheets showed the following losses in weight after 61 days in sodium chloride ( $\text{NaCl}$ ) solution of the following concentrations:

|        |      |           |
|--------|------|-----------|
| 0.34/N | NaCl | .0015 mm. |
| 0.86/N | NaCl | .0024 mm. |
| 3.42/N | NaCl | .0029 mm. |

No effect of varying silicon content of the aluminium within the range 0.57 per cent to 0.86 per cent of silicon

was noticed upon the type or amount of corrosion. It is not attacked by water in the absence of air or oxygen.

The corrosion is much increased as the temperature rises. For example, a sample of medium hard sheet

The Aluminum Company of America (12) states that aluminium "withstands the action of sea water better than iron, steel or copper. Strips of aluminium placed upon the sides of a wooden vessel were found

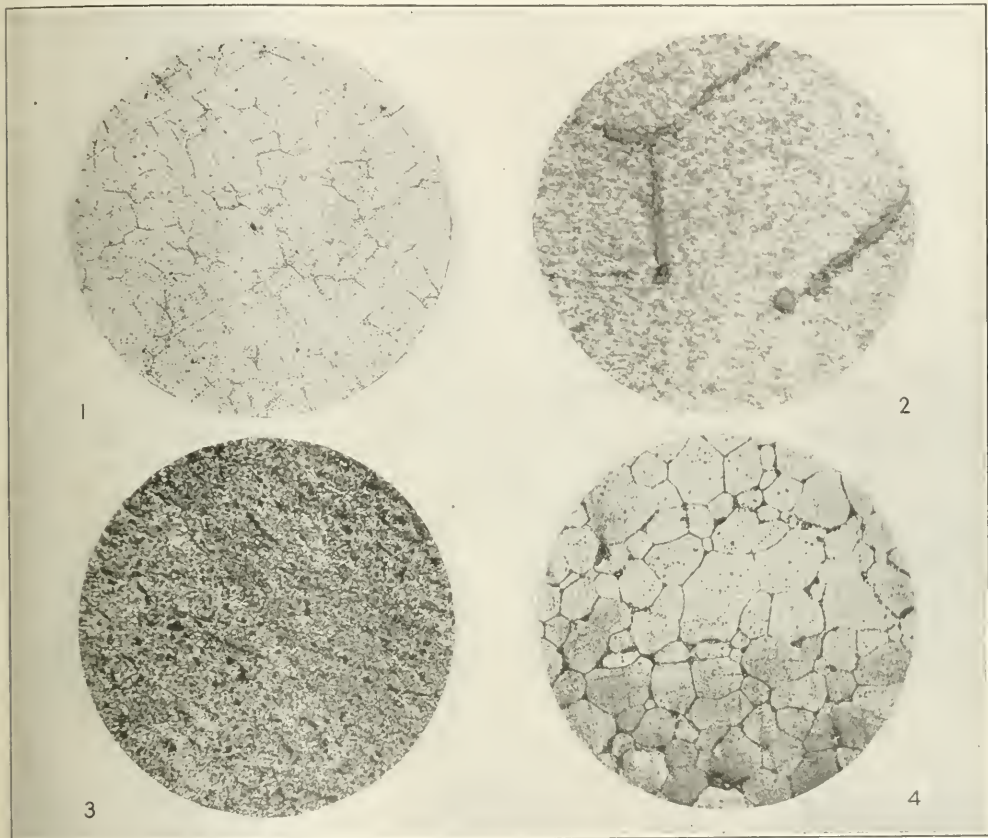


FIG. 1—NINETY-NINE PER CENT ALUMINIUM INGOT; ETCHED WITH 0.10% NaOH; x 100  
FIG. 3—HARD-ROLLED ALUMINIUM SHEET (ANDERSON, 96); ETCHED WITH HF; x 100

FIG. 2—ALUMINIUM INGOT; ETCHED WITH 0.10% NaOH; x 1000  
FIG. 4—ANNEALED ALUMINIUM SHEET (ANDERSON, 96); ETCHED WITH HF; x 50

showed the following decrease in thickness after 48 days in tap water:

|           |            |
|-----------|------------|
| at 20° C. | .00039 mm. |
| at 70° C. | .0011 mm.  |

Bailey (121) finds that the presence of copper and sodium in it increases the corrosion of aluminium, and that in general the greater the purity of the metal the less the corrosion.

Guillet (123) finds that soda solutions attack aluminium and its alloys very rapidly. A sample of aluminium which lost only 2 mg. weight after 8 weeks in Seine water lost 3.95 grams after the same time in a 1 per cent soda solution. Alloys containing copper are much more readily attacked than pure aluminium and he corroborates Heyn's claim that in general cold worked or hard aluminium resists attack less than the soft or annealed metal.

to be corroded less than .005 in. after 6 months exposure to sea water. Copper sheet treated similarly was corroded nearly twice as much."

2. PROTECTION OF ALUMINIUM AGAINST CORROSION

Both aluminium and its alloys are attacked by sea or salt water; the alloys of aluminium are attacked also by fresh water in which aluminium is much more stable. In order therefore to be able to utilize these alloys for construction purposes some method of protection against corrosion must be sought.

Of particular significance is the question of the protection of such alloys against corrosion in aircraft construction. Frames, beams and struts for rigid dirigible construction have already been made entirely from aluminium alloys and it is quite possible that similar construction will be tried for aeroplane construction to



replace parts now fabricated of wood, since there is now no doubt of the mechanical superiority of the alloy, duralumin, weight for weight, to wood or steel. An objection often raised against the use of these alloys is that they will corrode when exposed to the weather for any length of time.

Although it is impossible to electroplate aluminium, the effectiveness of such a coating is highly questionable. The coatings on aluminium do not adhere satisfactorily, and the metals used are all electronegative to the aluminium, such that if the coating were once punctured the corrosion at that point would be to a great degree accelerated.

The use of a paint, varnish or enamel seems the most promising solution of the problem. Some experiments carried out by Sabin in 1896 (135) will indicate how far the protection of aluminium by such means is possible today.

Sabin carried out two series of tests using in the first series 30 plates of aluminium and aluminium alloy and 25 plates in the second set. These were coated with various paints, enamels, and varnishes, suspended in cages: (1) in the first series, from 5 to 6 ft. below the water level in New York Navy Yard for 6 months; (2) in the second series, for 2 years in the water of the Norfolk Navy Yard, and about 13 months in the New York Navy Yard. The first series of tests showed that several coatings, namely, "Sabin process" pipe-coating enamel, baked; "Durable metal coating," both baked and unbaked; chromium oxide in Kauri resin oil-varnish, unbaked; Spar varnish, baked and unbaked; white zinc in Kauri resin oil-varnish, gave practically perfect protection to the 5 alloy series. In many cases blisters had formed in the coating, but no corrosion had set in. The same plates were again immersed in the water at the New York Navy Yard in 1897 for about 13 months; some of them were lost, but those which were not were recovered and upon examination were found to be still uncorroded.

The same may in general be said about the results of the second series of tests, although some of the coatings, notably those made with oil alone as a vehicle were destroyed by this exposure. Many remained absolutely intact, while during the same time heavy iron supporting chains were completely rusted away. The general conclusion from these tests is that aluminium and its alloys can be efficiently protected against corrosion under most severe conditions by the use of an enamel or varnish paint (the oil paints proved very inferior in these tests), and this fact, the result of extensive tests, is recommended to the attention of the aeronautical engineer for his investigation.

#### IV. PHYSICAL PROPERTIES

There are given below the best values available for the most common physical properties of commercial purest aluminium:

The density of annealed aluminium is 2.702; that of cold worked metal, 2.70.

The electrical resistivity is 2.828 microhm cm.; this corresponds to 60.3 per cent of the electrical conductivity of annealed copper (International Standard).

The temperature coefficient of electrical resistivity at 20 deg. is .0039.

The thermo-electromotive force of aluminium to copper (Northrup, 156) is given by the formula

$$10^6 E = 4.51 t - 0.0122 t^2 + 0.0000433 t^3.$$

The electrolytic solution potential of aluminium to a normal solution of its normal salts with sulphuric, hydrochloric and nitric acids respectively is +1.040, +1.015 and +0.775 volts (Neumann, 160).

The magnetic susceptibility of aluminium is  $+0.65 \times 10^6$  (Honda, 161).

Aluminium melts at 658.7° (Bureau of Standards, 163), and boils, under atmospheric pressure, at about 1800°C. (Greenwood, 164).

The heat of fusion of aluminium is approximately 64 cal. per gram (Laschtscheno, 98).

The thermal conductivity of aluminium at 18° C is .504 cal. per 1 deg. C., per second, per cubic centimeter (Lees, 166).

The thermal expansivity of aluminium may be represented by the following equation (Bureau of Standards):

$$\frac{\Delta l}{l_0} \text{ (between 0 deg. and 300 deg. C.)} = (22.3 t + .011 t^2) 10^{-6}.$$

The specific heat of aluminium at 18°C. is .2143 cal. per gram, degree C. (Jaeger and Dieselhorst, 153). It may be represented between 0° and 100°C. by the equation

$$s = .2124 + .000104 t.$$

The total heat required to heat aluminium from 0°C. to its melting point is 187 cal. per gr. (Latschenko, 98).

The optical reflecting power of aluminium for  $\lambda$  is .583  $\mu$  is 83 per cent (Drude, 181).

#### V. MECHANICAL PROPERTIES.

*Elasticity.* The best values for E, the (Young's) modulus for elasticity are given by Brislee (183) for 99.3 per cent aluminium bars and wire. This mean value is

$$E = 9,810,000 \text{ lb./sq. in at } 17^\circ\text{C.}$$

$$\text{for bars, } E = 9,840,000 \text{ lb./sq. in.}$$

$$\text{for wire, } E = 9,790,000 \text{ lb./sq. in.}$$

Koch and Dannecker (182) gives the following values for the modulus (F) of torsion ( $E = (\text{aprox.}) 2.72 F$ ) at higher temperatures:

| Temperature, °C. | Modulus of Torsion,<br>Lb. per 1 Sq.In. |
|------------------|-----------------------------------------|
| 20 .....         | 3,870,000                               |
| 100 .....        | 3,730,000                               |
| 200 .....        | 3,450,000                               |
| 300 .....        | 3,100,000                               |
| 400 .....        | 2,630,000                               |
| 450 .....        | 2,030,000                               |
| 500 .....        | 680,000                                 |

Poisson's ratio ( $\mu$ ) is given by Cardani (185) as .363, by Schaefer as .359. A mean value of .36 may be accepted. (Katzenelsohn finds that  $\mu$  increases 15.7% between 0° and 100°C.

*Tensile Test.* Aluminium may best be "normalized" by mechanical working (rolling, drawing, forging) followed by annealing at about 400°C. In this, soft state it possesses the following mean tensile properties:

|                                              |
|----------------------------------------------|
| Tensile strength 12,500 to 15,000 lb./sq. in |
| 8.78 to 10.54 kg./sq. mm.                    |
| Yield point 8000 to 9000 lb./sq. in.         |
| 5.52 to 6.32 kg./sq. mm.                     |
| Elongation in 2 in. .... 10–40%              |
| Reduction of area. .... 20–30%               |

The following table (No. 1) will give an idea of the tensile properties of this metal in other forms.

TABLE I—TENSILE PROPERTIES OF ALUMINIUM (1)

| Form        | Tensile Strength | Tensile Test Yield Point | Elongation in 2 In. | Reduction of Area |
|-------------|------------------|--------------------------|---------------------|-------------------|
| Sand cast   | 11,000-13,000    | 8,500                    | 15-25               | ...               |
| Chill cast  | 12,000-14,000    | 9,000                    | 15-25               | ...               |
| Sheet:      |                  |                          |                     |                   |
| Annealed    | 12,000-15,000    | 8,000-9,000              | 12-35               | 20-30             |
| Half-hard   | 18,000-22,000    | 9,000-12,000             | 5-12                | 20-30             |
| Hard        | 22,000-35,000    | 12,000-25,000            | 1-7                 | 20-30             |
| 12 gage     | 25,000           | ...                      | 7                   | ...               |
| 16 gage     | 28,000           | ...                      | 5                   | ...               |
| 20 gage     | 30,000           | ...                      | 3                   | ...               |
| Bars (hard) | 28,000-35,000    | 14,000-23,000            | ...                 | 30-40             |
| Wire (hard) | 25,000-55,000    | 16,000-33,000            | ...                 | 40-60             |
| 40 mil      | 31,000           | ...                      | ...                 | ...               |
| 80 mil      | 28,000           | ...                      | ...                 | ...               |
| 120 mil     | 25,000           | ...                      | ...                 | ...               |
| 200 mil     | 22,000           | ...                      | ...                 | ...               |

(1) These figures are by the Aluminum Co. of America (12), and others.

Gavey (196) has found that the duration of application of stress has a marked effect on the ultimate tensile stress. Hard drawn aluminium wires which had been in service as electrical conductors for a few months and had become somewhat corroded showed the following ultimate tensile stress:

| Time of Application of Ultimate Breaking Load | Breaking Load, Lb. | Tensile Stress (1), Lb. Sq. In. |
|-----------------------------------------------|--------------------|---------------------------------|
| Ordinary tensile test                         | 325                | 25,300                          |
| 1 hour                                        | 300                | 23,300                          |
| 2 hours                                       | 280                | 21,800                          |
| 118 hours                                     | 240                | 18,700                          |
| 525 hours                                     | 220                | 17,100                          |
| 1,900 hours                                   | ...                | Not broken but still stretching |

(1) Wire weighed 75 lb. per mile—was, therefore, apparently No. 10 British wire gage—values in column 3 calculated on this basis.

**Compression test.** The behavior of aluminium in compression is described by the Aluminum Co. of America (12) as follows:

Elastic limit (1) ..... 6000-25,000 lb./sq. in.

Ultimate strength (1) 16,000-100,000 lb./sq. in.

Elmendorf (189) finds an average value (11 tests) of 67,000 lb./sq. in. for the ultimate strength of cast aluminium.

**Hardness.** The selerescope hardness (magnifying hammer) of annealed or of cast aluminium varies from 4 to 6. The hardness of cold-rolled sheets is increased to from 13 to 15; the Brinell hardness (500 kg., 10 mm. ball, 30 seconds) of cast aluminium varies from 23 to 28.

**Ductility (Erichsen test).** The ductility of soft annealed aluminium sheets, such as are used for stamping and drawing is well indicated by the Erichsen test. Average Erichsen values (187, 188) are given below for different gages of commercial aluminium sheets:

| B.&S. Gage | Thickness in In. | Erichsen Value |
|------------|------------------|----------------|
| 28         | 0.0126           | 5.5-7.5        |
| 26         | 0.0159           | 7.0-8.0        |
| 24         | 0.0201           | 7.0-8.5        |
| 22         | 0.0253           | 7.0-8.5        |
| 20         | 0.0319           | 7.5-9.0        |
| 18         | 0.0403           | 8.0-9.5        |
| 16         | 0.0508           | 9.0-10.5       |
| 14         | 0.0640           | 10.0-11.5      |
| 12         | 0.0808           | 10.5-12.0      |
| 10         | 0.1018           | 11.0-12.5      |

**Alternating stress test.** The only tests of which results are published are those on the White-Souther machine by Elmendorf (189), on cast aluminium of tensile strength averaging 15000 lb./sq. in. He finds the following relation:

$$S = 48,000 R^{-0.113}$$

$$S = \text{fiber stress}$$

$$R = \text{No. of reversals to rupture.}$$

This gives for 10,000 lb./sq. in. fiber stress, one million reversals, for 7800 lb./sq. in., ten million reversals.

## MISCELLANEOUS

**Density.** Seven samples of hard drawn wire of from 99.52 to 99.60 per cent aluminium, tested at this Bureau

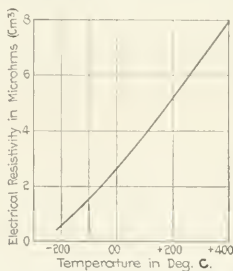


FIG. 5—EFFECT OF TEMP. ON ELECTRICAL RESISTIVITY OF ALUMINIUM (NICCOLAI)

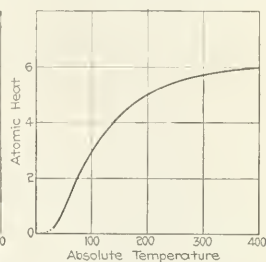


FIG. 6—EFFECT OF TEMP. ON ATOMIC HEAT OF ALUMINIUM (NERNST)

TABLE II—EFFECT OF TEMPERATURE ON THE ELECTRICAL RESISTIVITY OF KAHLBAUM ALUMINIUM (NICCOLAI, 265)

| Temperature in °C. | Electrical Resistivity in Microhm-Cm. | Temperature in °C. | Electrical Resistivity in Microhm-Cm. |
|--------------------|---------------------------------------|--------------------|---------------------------------------|
| +189               | 0.641                                 | +125               | 4.192                                 |
| +175               | 0.795                                 | +150               | 4.496                                 |
| +150               | 1.038                                 | +175               | 4.827                                 |
| +125               | 1.282                                 | +200               | 5.172                                 |
| +100               | 1.535                                 | +225               | 5.518                                 |
| +75                | 1.782                                 | +250               | 5.850                                 |
| +50                | 2.067                                 | +275               | 6.204                                 |
| +25                | 2.321                                 | +300               | 6.559                                 |
| +0                 | 2.618                                 | +325               | 6.917                                 |
| +25                | 2.925                                 | +350               | 7.274                                 |
| +50                | 3.237                                 | +375               | 7.638                                 |
| +75                | 3.562                                 | +400               | 7.991                                 |
| +100               | 3.858                                 |                    |                                       |

TABLE III—TENSILE TESTS OF HARDDRAWN ALUMINIUM TUBES (BREUIL, 204)

(a) Effect of annealing. (1)

| Temperature of Anneal °C. | Tensile Strength, Lb. per Sq. In. | Tensile Properties Yield Point, Lb. per Sq. In. | Elongation in 2.7 Cm. % | Reduction of Area, % |
|---------------------------|-----------------------------------|-------------------------------------------------|-------------------------|----------------------|
| Hard                      | 31,600                            | 30,800                                          | 4.0                     | 18                   |
| 100                       | 35,800                            | 31,600                                          | 6.6                     | 15                   |
| 200                       | 31,600                            | 18,100                                          | 5.6                     | 31                   |
| 300                       | 21,600                            | 15,000                                          | 22.2                    | 42                   |

(1) Tubes were annealed in oil (time not given) and tested.

(b) Effect of temperature on properties.

| Temperature of Anneal °C. | Tensile Strength, Lb. per Sq. In. | Tensile Properties Yield Point, Lb. per Sq. In. | Elongation in 2.7 Cm. % | Reduction of Area, % |
|---------------------------|-----------------------------------|-------------------------------------------------|-------------------------|----------------------|
| 20                        | 31,600                            | 30,800                                          | 4.0                     | 18                   |
| 100                       | 29,900                            | 29,900                                          | 9.6                     | 24                   |
| 200                       | 20,800                            | 15,800                                          | 22.2                    | 41                   |
| 300                       | 10,100                            | 10,100                                          | 31.4                    | 35                   |

TABLE IV—TENSILE TESTS OF ALUMINIUM BARS AT HIGHER TEMPERATURES (1) (BAUMANN 201)

| Temperature, °C. | Tensile Strength, Lb. per Sq. In. | Elongation in 2.7 Cm. (1.97 In.) | Reduction of Area |
|------------------|-----------------------------------|----------------------------------|-------------------|
| 20               | 14,000                            | 43.3                             | 64.5              |
| 60               | 12,600                            | 49.9                             | 71.9              |
| 100              | 9,860                             | 66.8                             | 76.6              |
| 200              | 5,980                             | 78.1                             | 87.2              |
| 300              | 3,360                             | 79.8                             | 92.8              |
|                  | Not Annealed                      |                                  |                   |
| 20               | 19,900                            | 16.3                             | 43.7              |
| 100              | 13,700                            | 35.8                             | 66.0              |
| 200              | 9,230                             | 44.7                             | 76.9              |
| 300              | 4,270                             | 59.9                             | 83.7              |

(1) These tests were made on 99% aluminium bars 17, 12, 8 and 4 mm. thick. The values given are averages of the results for the bars of the 4 thicknesses.

TABLE V—EFFECT OF TEMPERATURE ON THE TENSILE PROPERTIES OF ALUMINIUM (BENGOUGH, 200). (THE METAL TESTED CONTAINED 99.56% AL)

| Temperature of Test, °C. | Tensile Strength, Lb. per Sq. In. | Tensile Properties Yield Point, Lb. per Sq. In. | Elongation in 2 In. % | Reduction of Area, % |
|--------------------------|-----------------------------------|-------------------------------------------------|-----------------------|----------------------|
| 20                       | 19,200                            | 12                                              | 75                    | 75                   |
| 200                      | 14,100                            | 15                                              | 78                    | 78                   |
| 275                      | 11,110                            | 17.2                                            | 79                    | 88                   |
| 330                      | 7,600                             | 20.3                                            | 88                    | 88                   |
| 375                      | 3,800                             | 25                                              | 90                    | 96                   |
| 396                      | 2,150                             | 65                                              | 96                    | 96                   |
| 520                      | 900                               | 88.5                                            | 96                    | 96                   |
| 565                      | 540                               | 70.3                                            | 96                    | 96                   |
| 610                      | 660                               | 75.0                                            | 96                    | 96                   |
| 625                      | 420                               | 39.0                                            | 96                    | 96                   |

averaged 2.6991 in density, ranging from 2.6983 to 2.6996 (151). Brislee (143, 144) has shown that the density of aluminium depends upon the heat treatment

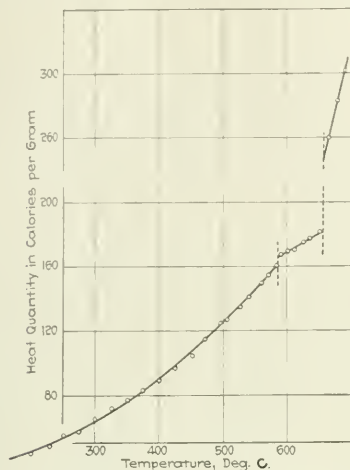


FIG. 7—TOTAL HEAT IN ALUMINIUM BETWEEN 2°C. AND 24°C. (LASCHITSCHENKO)

and amount of mechanical working it has suffered. He found that the mean increase of 7 samples of density of cold worked metal upon annealing was 0.0017 or 0.063 per cent. Annealed aluminium may be regarded as having a density of 2.702, cold worked or hard aluminium one of 2.700.

#### VI. PHYSICAL PROPERTIES AT HIGHER AND LOWER TEMPERATURES.

Niccolai (205) has determined the specific electrical resistivity of aluminium at temperatures from  $-180^{\circ}\text{C}$ .

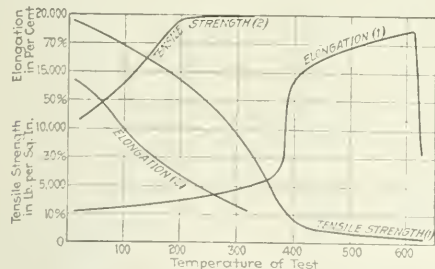


FIG. 8—EFFECT OF TEMPERATURE ON TENSILE PROPERTIES OF ALUMINIUM (BAUMANN) (BENGOUGH)

to  $400^{\circ}\text{C}$ . His values are given in Table 2 and plotted in Fig. 5. Lees (166) also gives similar values for the electrical resistivity at lower temperatures.

The effect of low temperatures upon the atomic heat of aluminium is shown in the Fig. 6 from data by Nernst (202).

The total heat of aluminium at higher temperatures has been measured by Laschtschenko (98) from  $t^{\circ}$  to  $24^{\circ}\text{C}$ . His results are plotted in Fig. 7.

Lees (166) gives the following values for the thermal conductivity of 99 per cent aluminium.

| Temperature in $^{\circ}\text{C}$ . | Thermal Conductivity in Cal. per Sec.—per $\text{Cm}^2$ —per $1^{\circ}\text{C}$ . |
|-------------------------------------|------------------------------------------------------------------------------------|
| -170                                | 0.524                                                                              |
| -160                                | 0.514                                                                              |
| -150                                | 0.508                                                                              |
| -125                                | 0.491                                                                              |
| -100                                | 0.492                                                                              |
| -75                                 | 0.493                                                                              |
| -50                                 | 0.496                                                                              |
| -25                                 | 0.499                                                                              |
| 0                                   | 0.502                                                                              |
| +18                                 | 0.504                                                                              |

Investigation has been made by Breuil (204), Baumann (201), and Bengough (200), of the effect of temperature on the tensile properties of aluminium. Their results are shown in the Tables 3, 4 and 5, and in Fig. 8. The variation in the results is due in all probability to the difference in the speed of testing which has undoubtedly much effect on the results obtained.

(To be Continued)

### Asphalt and Petroleum Residues in 1917

Statistics just completed under the supervision of J. D. Northrop of the U. S. Geological Survey show a marked decrease in the production of maltha, gilsonite, elaterite and grahamite, bituminous rock, and ozokerite—\$0,904 tons valued at \$735,924 being produced, which is 17,570 tons less than in 1916.

The quantity of manufactured asphalt (including road oils and flux) produced in 1917 from petroleum of domestic origin increased about 2 per cent compared with 1916, and the quantity of corresponding material manufactured in this country from Mexican petroleum increased about 13 per cent, as a consequence of which the net gain over the production in 1916 was nearly 7 per cent.

The total sales in 1917 of manufactured asphalt derived from domestic petroleum amounted to 701,809 short tons, valued at \$7,734,691. This total includes 327,142 tons, valued at \$4,011,980, of solid and semisolid products used in the paving and roofing industries, and 374,667 tons, valued at \$3,722,711, of liquid products, including road oils, flux, and asphaltic paints.

California maintained its supremacy in the production of oil asphalt. Its output from 14 petroleum refineries in 1917 aggregated 220,294 tons, valued at \$2,100,252, and included 135,160 tons of solid and semisolid products, valued at \$1,486,609, and 85,134 tons of liquid products, valued at \$613,643. Refiners handling oil from the Oklahoma-Kansas field produced 206,223 tons of oil asphalt, valued at \$1,975,493, including 73,410 tons of solid and semisolid products, valued at \$747,651, and 132,813 tons of liquid products, valued at \$1,227,842.

The total sales in 1917 of manufactured asphalt derived from Mexican petroleum amounted to 645,613 short tons, valued at \$7,441,813, and included 338,485 tons of solid and semisolid products, valued at \$4,657,152, and 307,128 tons of liquid products, valued at \$2,784,661.

The imports of native asphalt, oil asphalt, and bituminous rock for consumption in the United States in 1917 aggregated 187,886 short tons, valued at \$993,115, a gain in quantity of 40,173 tons, or 28 per cent, over 1916. The exports of unmanufactured asphalt in 1917 amounted to 30,107 short tons, valued at \$587,256, a loss of 10,709 tons, or 35 per cent, compared with 1916. In addition asphalt products to the value of \$585,472 were exported in 1917.



## The Deresination of Rubber

### A Resume of the Art of Improving Low-Grade Rubber by Removal of Resin—Outline of Processes Proposed—Deresination of Guayule May be Resumed in a Short Time

BY ANDREW H. KING

IN PREVIOUS papers the writer has pointed out that rubber may be represented by the chemical formula  $2(C_{10}H_{16})_n$ . The subscript  $n$  denotes the degree of polymerization on which depends, to a great extent, the value of the rubber, i.e., whether it is high- or low-grade.  $C_{10}H_{16}$  is the basic formula for the whole terpene series to which rubber is very closely related, if not actually a member, as was held by Weber. Many organic compounds, the terpenes in particular, possess the property of becoming resinified by oxidation in the air or under the influence of chemical reagents. In other words, they may be converted to substances very similar to the resins which occur in nature. The natural resins are solid, amorphous, and generally brittle masses which break with a conchoidal fracture. They are insoluble in water and acids, but soluble in acetone, alcohol, ether, turpentine, etc. They are found in the solid form in abundance and occur also as balsams; that is, dissolved in terpenes or etherial oils from which they can be separated by steam distillation. Resins dissolve in alkalies to form resin soaps but are precipitated when the solution is acidified. Most resins consist of a mixture of somewhat complicated acids, the so-called resin acids.

The resins of rubber are extremely complex and are but very imperfectly understood. Neither their origin nor their composition are definitely known. The only way in which they can yet be safely defined is that they are substances which may be extracted from crude rubber by acetone or alcohol, and contain varying amounts of oxygen.

In regard to the relation of resins to rubber, only three views are possible:

- (1) They are derivatives of rubber, oxidation products, etc.
- (2) They are terpene bodies of low polymerization.
- (3) They were produced by the plant at the time of the formation of rubber but by different reactions and are not related chemically to rubber.

The first view, i.e., that they are derivatives of rubber, is the one most generally held and is probably correct for high-grade rubbers, notably those obtained from *Hevea brasiliensis*. Tschirsch<sup>1</sup> states that the carbon and hydrogen in resins frequently stand in the same relation to one another as in rubber, which, since all resins contain oxygen, would indicate that they are oxidation products. Perhaps the best argument, however, is that the resins of *Hevea* rubber protect it from oxidation and subsequent tackiness. When they are removed by extraction and the rubber sheeted out thin and exposed to air it quickly grows tacky. If it

is again extracted it will be found to have regenerated its acetone soluble content. Oxidation is accelerated by ultraviolet light. If a thin sheet of rubber is exposed to air in the presence of ultraviolet light it becomes tacky and has a higher resin content than before exposure. This view is not concurred in by Hinrichsen and Marcusson, and probably will never be accepted as a general rule applying to all rubbers.

The second view is perhaps correct to a limited extent in all varieties of rubber. Probably when we understand the mechanism by which the plant produces caoutchouc we will be able to throw more light upon this theory. Many rubber resins, i.e., the acetone-soluble portion of rubber, are made up of two parts, a soft and a hard resin. These may often be separated by steam distillation, etc. The inference is that they are similar to the balsams which consist of a resin dissolved in an essential oil. The hard portion is likely an oxidation product of rubber similar to Spillers resin,  $C_{30}H_{48}O_{10}$ , or a separate substance produced by the plant by some other reaction. The soft material is probably a terpene with a low degree of polymerization, i.e.,  $(C_{10}H_{16})_n$  where  $n$  is very small.

The third theory is applicable to the resins obtained from highly resinous rubbers, particularly those obtained from *Dyera* varieties such as Jelutong, Pontianac, Dead Borneo, etc. In these varieties the function of the plant seems mainly to have been the production of resin with rubber merely as a by-product. Hinrichsen and Marcusson<sup>2</sup> attacked the question by investigating the optical properties of resins obtained from various rubbers. They found that all varieties examined except *Hevea* resin were optically active and dextro rotatory. They deresinated a sample of *Funtumia* rubber and exposed it to the air, bringing about oxidation and tackiness. On again deresinating they obtained 3.11 per cent of an inactive resin. The rotation for natural *Funtumia* resin is  $[\alpha]_D + 32.9$ . They concluded that since the oxygen derivative of rubber is optically inert this must be inert also and the active resins can not possibly be rubber derivatives. Optical activity is a characteristic property of the terpenes and the activity of natural resins is probably due to the presence of a small amount of such bodies.

#### PROPERTIES OF RESINS

*Resin Content of Various Rubbers:* The percentage of resin varies with the variety of tree and the care with which the rubber has been prepared. In general the more careful the coagulation the lower the resin content. Table I contains the resin contents and washing losses of certain rubbers as given by Spence<sup>3</sup>.

<sup>1</sup>Z. K. anorg. Chem. 22, 1916, p. 49.

<sup>2</sup>Proceedings, International Rubber Congress, 1914.

<sup>3</sup>Die Harze, 1906, vol. 1, p. 939.

Many others could be given but these are perhaps the most important. It should be mentioned here that Guayule and Jelutong (including Dead Borneo and Pontianack) where the only varieties ever detersinated on a commercial scale. The extraction of Jelutong yields such a large quantity of resin and so little rubber that it was early abandoned, at least as a source of rubber. The resin is valuable for certain purposes, and odd lots still find their way to the market.

**Ozonides of Resins:** Harries<sup>4</sup> states that a characteristic property of rubber resins is that they form ozonides insoluble in carbon tetrachloride and chloroform.

**Melting Point of Resins:** Most resins are liquid at ordinary temperatures. Dittmar<sup>5</sup> reports the following melting points:

|                   | Deg. C. |
|-------------------|---------|
| Congo Rubber..... | 74      |
| Borneo.....       | 92.5    |
| Madagascar.....   | 102     |

**Unsapnifiable Matter, Optical Activity, and Iodine Values:** The work of Hinrichsen and Marcusson has been mentioned above. The values obtained by them are as follows:

|               | Unsapnifiable Matter in Resin | Optical Rotation | Iodine Value |
|---------------|-------------------------------|------------------|--------------|
| Jelutong..... | 100%                          | (a) D + 50.9     | 30.6         |
| Cassia.....   | 92.5                          | Active           | .....        |
| Pedang.....   | 90.2                          | Active           | .....        |
| Guayule.....  | 78.2                          | (a) D + 12       | .....        |
| Kickxia.....  | 74.0                          | (a) D + 32.9     | .....        |
| Congo.....    | 56.0                          | (a) D + 12       | .....        |
| Ceylon.....   | 20.8                          | Inactive         | .....        |
| Para.....     | 15.0                          | Inactive         | 118.0        |

They found as a general rule that the more active optically the resin the more unsapnifiable matter it contained. The unsapnifiable matter in Upper Congo resin gave a rotation of  $[\alpha]_D + 24.5$ , while the sapnifiable constituent of the same resin gave only  $[\alpha]_D + 13$ .

#### CHARACTERISTICS OF CERTAIN RESINS

**Jelutong:** Dubosc<sup>6</sup> treated crude Jelutong with acetone and then with ether and obtained two products which after repeated crystallization were both shown to have the empirical formula  $C_{28}H_{48}O$ . They differed as follows: Melting points  $80^\circ$ - $82^\circ$ , and  $105^\circ$  C.; boiling points  $195^\circ$ - $200^\circ$ , and  $230^\circ$ - $290^\circ$  C. respectively; also in their solubility in acetone and chloral, and in their behavior with nitric and sulphuric acids. Dubosc considers that there is a simple relation between cholesterolin and purified Jelutong resins. He regards the latter as isomers of phytosterin or plant-cholesterin. Cholesterolin gives a characteristic color reaction with propionic anhydride. A blue color is first obtained which soon changes to red, then to green, then orange and finally red. With acetic anhydride a violet color is obtained, which eventually turns black. The resin propionate has a melting point of  $98$ - $100^\circ$  C. Cholesterolin propionate melts at  $98^\circ$  C. The resin acetate melts at  $110$  to  $112^\circ$  C. Cholesterolin acetate melts at  $113^\circ$  C. The resin acetate in common with cholesterolin acetate is sapnifiable with boiling water. The reactions of cholesterolin and Jelutong resin with sulphuric acid are analogous. Potassium permanganate, chromic acid, and sulphuric acid oxidize cholesterolin to acids soluble in ammonia. Jelutong, when boiled three or four hours

with the oxidizing mixture, is converted to cholesterolin acid, which is easily separated by means of ammonia. Fractional extraction of Jelutong with acetone in a Soxhlet yields three distinct products, melting at  $141^\circ$  C.,  $115^\circ$  C., and  $103^\circ$  C. A mixture of equal parts of the resins melts at  $82^\circ$  C. These bodies are isomers and have the empirical formula  $C_{28}H_{48}O$ .

Schidrowitz states that Jelutong contains a white crystalline hard resin soluble with difficulty in cold, but readily in hot absolute alcohol, and a soft yellowish resin very readily soluble in cold alcohol. Technically, hard resins are preferable to soft. A resin content up to 8 per cent is not serious if it is mostly hard. Funtumia elastica, properly prepared, contains only hard resin. Schidrowitz is of the opinion that Jelutong resin is probably a compound of vegetable cholesterolin with cinnamic acid.

The following analytical data was obtained by the writer on old Pontianack resin obtained in the open market:

|                           | A             | B             | C <sup>a</sup>  |
|---------------------------|---------------|---------------|-----------------|
| Melting point.....        | $73^\circ$ C. | $82^\circ$ C. | $92.5^\circ$ C. |
| Acid value.....           | 3.5           | 4.1           | None            |
| Saponification value..... | 70.0          | 48.1          | 28.1            |
| Iodine value.....         | 43.2          | 44.0          | .....           |
| Acetone soluble.....      | 99.5          | 99.3          | .....           |

<sup>a</sup> Reported by Dittmar for Borneo.

**Guayule:** The Guayule shrub, *Parthenum Argentatum*, contains 8 to 10 per cent of rubber based on dry material. The commercial rubber contains 75 per cent of rubber hydrocarbons. The dry plant, according to Alexander,<sup>7</sup> yields about 6.5 per cent of a dark-green substance when extracted with acetone. Of this 54 per cent, 31 per cent and 15 per cent are successively dissolved on treatment with light petroleum, ether and hot alcohol. Of the three component parts thus separated 12.1 per cent, 7 per cent and 2 per cent consist of unsapnifiable matter. The acids produced by the hydrolysis of the extract include one melting at  $119^\circ$  C., which belongs to the cinnamic acid group and phenyl acetic acid. Weil states that he found cinnamic acid in products of hydrolysis of Guayule resin. The crude acetone extract on steam distillation yields a sesquiterpene alcohol melting at  $127$ - $128^\circ$  C., which has a camphor-like odor.

On distillation with steam Guayule rubber yields from  $\frac{1}{2}$  to 4 per cent of a volatile oil ( $15^\circ$  C. .8861) which is laevo-rotary. You will note that Hinrichsen found the resin to be dextro-rotatory. This oil possesses a peculiar pepper-like aroma and consists almost wholly of hydrocarbons. On distillation at 17 mm. pressure it yields the following fractions:

|                                  | Per Cent |
|----------------------------------|----------|
| Between $50$ - $60^\circ$ C..... | 30.0     |
| $60$ - $80^\circ$ C.....         | 20.3     |
| $120$ - $160^\circ$ C.....       | 24.8     |
| Resinous residue.....            | 5        |

The first fraction is mainly l-piylene and the third a sesqui-terpene. No styrene is present. The above relates to the oil distilled from fresh Guayule. Oil distilled from plants which have been stored for several years contained much oxygenated material and while piylene was obtained no sesqui-terpene fraction could be isolated. The presence of volatile oil in Guayule is the cause of the difficulty experienced when the rubber was first used on an industrial scale, since it hinders vulcanization. The oil also causes trouble because of

<sup>6</sup>G. 2, 1910, vol. xxiv, p. 850.

<sup>7</sup>G. 2, 1907, vol. xxi, p. 666.

<sup>8</sup>La Caout. et la Gutta Percha, 1911, 8, 5756-5761.

<sup>9</sup>Ber. 1911, 4, 2320-2328.

its dissolving action on rubber during vulcanization. It tends to break down the rubber and depolymerize it. Guayule can be used in small quantities blended with other rubbers, but if it is to be employed alone it should be deresinated.

The following analytical figures are the average of results obtained by the writer with fresh Guayule resin over a long period of time:

|                      | Per Cent |
|----------------------|----------|
| Isoline value        | 57.5     |
| Saponification value | 61.1     |
| Acid value           | 20.5     |
| Unsaponifiable       | 50.1     |

### FUNCTION OF RESINS

In low-grade rubber the resin functions simply as a diluent. The rubber secured by deresination of Guayule, Pontianack, Jelutong, Palembang, or Dead Borneo is in every case of good quality, being about on a par with Brown Crepe. In high-grade rubbers, such as the plantation and Para varieties derived from the *Hevea brasiliensis* tree, the function of the resin is entirely different. The first effect is to protect the crude rubber against oxidation. Deresinated Hevea rubber when exposed to the air soon becomes tacky. The second is to assist in vulcanization. Deresinated Hevea rubber cured with sulphur requires a longer time or higher sulphur content than is customary. The acetone-soluble material from this variety of rubber is a good accelerator. The presence of resins is apparently necessary if the mineral accelerators are used. L. E. Weber<sup>1</sup> was unable to obtain a good vulcanization with deresinated rubber, sulphur, and litharge. The presence or absence of resin has very little effect on the time of cure if organic accelerators are used. The accelerating effect of Hevea resin has now been shown to be due to nitrogenous matter which is soluble in acetone. The influence of proteins and other nitrogenous materials has been well discussed by Dubosc, Eaton and Grantham, Beadle and Stevens, and others, to whose writings the interested reader is referred.

### FEASIBILITY OF DERESINATION

As indicated above, only low-grade rubbers were deresinated on a commercial scale; and of these only Guayule and the rubbers from *Dyera costulata* (namely: Jelutong, Pontiniac, Palembang and Dead Borneo) ever came into any prominence in this field.

Chute,<sup>2</sup> in estimating the cost of deresinating guayule in 1909 by his process, to be mentioned later, assumed that a grade yielding 60 per cent of purified gum could be purchased at 30c. per pound. He placed the solvent cost at 3c. per pound and the working cost also at 3c. per pound. One pound of Guayule would yield .6 pounds of gum at a cost of 36c., which made the cost per pound of finished gum 60c. The market price of guayule is still around 30c. per pound, but of course solvents, particularly acetone, are much higher. On the other hand, however, chemical engineering practice has made great progress within the past nine years. With modern apparatus the solvent loss should be reduced almost to zero. Based on a process later to be discussed, using gasoline and acetone, the solvent loss was seldom less than 15 gallons of acetone and 44 gallons of gasoline per 1000 pounds of good rubber produced.

The supply of Pontianack is today almost exhausted. This is due solely to the wasteful and extremely primeval methods used by the natives in securing the gum. Where they might have tapped trees and built up a steady business they felled and bled them at many different points. The method produced quick results but the procedure reminds one of the old fable about killing the goose that laid the golden egg. In 1909 a good grade of Ponti could be secured at 5c. per pound. The market price is now around 30c. per pound, making Ponti no longer a profitable purchase.

Chute<sup>3</sup> in 1909 estimated the cost of deresinating Ponti as follows: "Assuming that Pontianack can be bought for 5c. per pound and that it yields one pound of purified gum from ten pounds of the crude, then the materials cost (by his process) for the rubber will be 50c. per pound for the finished product. If one gallon of solvent per pound of crude gum is used and the solvent is worth 75c. and the loss is one per cent, then the cost for loss of chemicals calculated on the finished product would be 7.5c. per pound. The cost for labor and other expenses for a moderate-sized factory should not exceed 5c. per pound of finished product. This would give a total cost per pound of 62.5c." Crute based his estimate on the use of certain methyl and ethyl esters, but the figures are typical of results obtained in the past.

The deresination of Ponti is now not to be thought of, but aside from patriotic reasons the treatment of guayule should be a good business proposition. It is not nearly so difficult as the treatment of a low-grade gold ore. There is no reason why it cannot be successfully and profitably accomplished if suitable chemical engineering talent be obtained.

#### Statement of the Problem:

1. To deresinate guayule, one must reduce the resin content from approximately 25 to about 2 per cent.
2. The rubber must not suffer in quality by excessive heating or by detrimental action of any solvent or reagent.
3. Solvent and rubber losses must be kept as low as possible.
4. The operation must be accomplished in as short a time and with as few treatments as possible.

*Processes:* Many processes have been proposed in the past. They may all be classified under the following heads:

1. Those which depend on the action of alkali on the resins.
2. Those employing a mixed solvent which at high temperatures will dissolve rubber, but at lower temperatures is a better resin solvent.
3. Those processes which use a rubber solvent for dissolving both rubber and resin and then precipitate out the rubber by adding a resin solvent in which rubber is insoluble.
4. Those which first extract the resin and later remove the rubber from woody material, such as occurs in guayule, by a suitable rubber solvent.
5. Those which employ a solvent for resin without at any time dissolving or otherwise affecting the rubber.
6. Those which use a mixed solvent consisting of a rubber and a resin solvent. The first swells the rubber and the second removes the resin.

<sup>1</sup>Eighth Int. Cong. Applied Chem., 1912, vol. ix.

<sup>2</sup>H. O. Chute, "Deresination of I. R.," *J. I. R. W.*, June, 1909.



### 1. Alkali:

Processes using alkali depend upon the fact that certain of the rubber resins are partly saponifiable. Guayule resin, as reported by Hinrichsen (see above), is about twenty-two per cent saponifiable. Chaplet and Rousset<sup>10</sup> state that washing rubber with alkali after deresination removed some albuminoids and oxydases which would otherwise turn it black and oxidize it. Treatment with alkaline solutions is not a practical proposition; first, because it removes only a small part of the resin; and second, the removal of all the alkali is almost impossible. Even traces of caustic behave as unregulated accelerators, causing the stock to harden up and surface check on standing.

However, the first deresinating patents granted in this country were to Austin Day<sup>11</sup> in 1856 for purifying rubber gums by treatment with alkaline solutions. In 1857 Roberts Haerting received U. S. Pat. No. 17,214 for purifying gutta percha by the action of an alkaline liquor which, as he claims, dissolves out the etheric oil. In 1903 W. A. Lawrence received a series of patents beginning with U. S. Pat. No. 741,256 covering the extraction of rubber from plants (guayule) by treatment first with naphtha and then with a solution of caustic soda. No. 741,258, issued August 20, 1902, refers to a process by which the rubber is removed from the plants by mechanical means and the resins then dissolved by alkali or alcohol.

### 2. Solvent which will dissolve rubber at high temperatures:

This method is really much better suited to gutta percha than to rubber. Eng. Pat. 22,758 was granted in 1901 to Combanaire and de la Fresnaye and covers the purification of gutta percha by treatment with naphtha which at certain temperatures dissolves gutta resins. A similar patent<sup>12</sup> was granted to Wilmonsky in 1901 for a process of refining gutta percha, which consisted in dissolving the entire gum in hot gasoline and cooling to 60° F. when it was claimed if four gallons of naphtha or more were used for each pound of gum a flocculent precipitate was formed which consisted of pure gum.

Under this head may also be placed those processes which use pyridine. U. S. Pat. 983,812 granted to Drefus, Friedl and Bentley in March, 1910, describes a process wherein crude rubber is treated with six times its weight of pyridine base oil (boiling between 130 and 220° C.) and an equal weight of water. The mixture is agitated and heated to about 100° C. under a reflux condenser for 2 to 4 hours. Owing to the fact that pyridine even at this temperature dissolves appreciable quantities of rubber the process was never a commercial success.

### 3. Dissolve both rubber and resin, then precipitate the latter:

In February, 1906, a German patent was granted to Gratz covering a process in which the crude rubber was treated with benzine, turpentine, carbon bisulphide or gasoline, which dissolve both rubber and resin. The rubber is precipitated by the addition of methyl, ethyl or amyl alcohol which holds the resins in solution.

U. S. Pat. 978,696 issued to L. H. Chanut in June, 1910, describes the successive treatment of crude gum

with carbon bisulphide and acetone. For 100 Kg. of crude in all 227.5 litres of carbon bisulphide and 334.1 of acetone were required. The gum was first worked in a dough mixer with 50 litres of carbon bisulphide; later 40 litres of acetone were added and mastication continued. The mixture of solvents was poured off, 97.5 litres of CS<sub>2</sub> added, and mastication resumed. After a time 50 litres of acetone were added, thus precipitating the rubber. The solvents were poured off and 20 litres more of acetone added, which was poured off after a brief mastication. The third and fourth treatments began with 40 litres of CS<sub>2</sub>, followed by 56 litres of acetone. The mixed solvents were poured off and 56 litres of acetone added in each case as a sort of after-wash to remove resins and granulate the rubber.

Another process belonging in this group is that of Lawrence,<sup>13</sup> in which guayule which had been previously removed from wood by solution in naphtha was treated with alcohol which precipitated the rubber and dissolved the resin. After thoroughly washing the rubber to remove the last of the resin the solution was evaporated, leaving the resin behind in the kettle.

### 4. Extraction of the resin, followed by removal of the rubber from the wood:

This process is the opposite of that of Lawrence mentioned above. Foelsing<sup>14</sup> proposed to extract the ground Guayule shrub with acetone followed by removal of the rubber by solution in naphtha. The solvents were removed by evaporation.

Both these processes are of rather questionable value owing to the fact that they could only be carried on in the region where Guayule is harvested, which territory is not very satisfactory for extensive chemical operations. The solution processes for separation of rubber from Guayule shrub have nearly all been abandoned in favor of mechanical methods.

### 5. Extraction with a resin solvent:

These processes are modifications of analytical procedure for determining the percentage of resin in crude rubber, which subject was investigated by C. O. Weber,<sup>15</sup> who concluded that acetone is the most satisfactory resin solvent, and states that it will, particularly at higher temperatures, easily dissolve all the resinous constituents of rubber, gutta percha, and balata without dissolving a trace of any of these bodies themselves. The processes under this head involve the extraction of rubber with acetone, alcohol, or other resin solvent which does not attack the gum.

The first patent granted in this country in which definite claim to deresination of rubber was made, was the one previously mentioned which was granted to Lawrence<sup>16</sup> in 1902. It involved the treatment of guayule containing some naphtha with alcohol. The extracting plant consisted of a churn which was provided with a corrugated bottom with corrugated rollers which in passing over it masticated the rubber in the presence of the solvent. The saturated liquid was removed to a still, the acetone and naphtha evaporated and run into tanks for further use, leaving the resin behind.

A process closely related to analytical practice is that of Eves<sup>17</sup> in which a car containing rubber is exposed

<sup>10</sup>LeCaout, *et la Gutta Percha*, Feb. and Mar., 1911.

<sup>11</sup>U. S. Pat. 15,067.

<sup>12</sup>U. S. Pat. 673,320.

<sup>13</sup>U. S. Pat. 741,260, Mar. 1902.

<sup>14</sup>French Pat. 368,958 (1906).

<sup>15</sup>"Chemistry of India Rubber."

<sup>16</sup>U. S. Pat. 821,934, issued 1906.

to the vapors of alcohol or acetone which pass through and around the mass which is worked by rotating arms within the car. The condensate falls from the condenser upon the rubber, thus giving extraction at or near the boiling point of the solvent, which point was particularly recommended by Weber.<sup>15</sup> At least one large plant was successfully operated under the Eves patent and several hundred tons of rubber were treated by this process.

Practically all deresinating plants in operation in this country in 1912 used acetone as the resin solvent. Of particular interest now are the patents of Chute<sup>16</sup> which cover the use of the acetic esters of ethyl and methyl alcohols. He states<sup>17</sup> that acetone will dissolve when hot only 18 per cent of Pontianack resin, some of which will crystallize out on cooling. Methyl acetate dissolves 25 per cent of the resin and ethyl acetate 50 per cent. These esters were used in conjunction with acetone. In other words, Chute discovered a mixed solvent which has no effect on rubber but holds a high percentage of resin. The chief objections to the use of these esters are their high price and the relatively small quantities available. Solvent loss was formerly quite a factor, but with modern apparatus this should be reduced to a negligible factor. If deresination by means of a resin solvent is decided upon the mixed solvents of Chute would probably be superior to acetone since smaller volumes of solutions could be handled, requiring less equipment and giving a lower solvent loss.

6. *Two solvents, one to swell the rubber, the other to dissolve the resin:*

The processes which come under this head were in general use and a rather large volume of deresinated Guayule was prepared in this way. The resin solvents employed were chiefly alcohol or acetone, while gasoline was used almost entirely for swelling the rubber. They were combined and used as a mixed solvent. The usual proportions were 47 per cent gasoline and 53 per cent acetone by volume.

You will note that the Lawrence<sup>18</sup> patent also comes under this classification. The idea is indicated, though rather imperfectly described, in French Pat. 404,307 (1909) to the Caoutchouc Co., which describes a process in which a little benzine is added to soften and swell the rubber to the gelatinous condition but not enough to dissolve it, after which acetone was employed to remove the resins. The process described later in this paper also comes under this classification.

*Apparatus:* All those who are familiar with the preparation of rubber cements realize that no solvent can properly act on large masses of rubber without constant mastication. This principle is of the greatest importance in deresination, no matter which process is used. Means must always be provided for bringing the solvent in intimate contact with the rubber. The closed vessel in which the rubber and solvent are worked together, usually by rotating arms or rollers, is called the churn.

U. S. Pat. 821,717 was issued to F. C. Hood in 1906 for such an apparatus. A set of ordinary rubber washing rolls were mounted in a water-tight covered chamber which was filled with deresinating liquid to a point above the rolls. The sheet of rubber was made to pass through the rolls, then up and through once more,

There is also a patent to Lawrence,<sup>19</sup> previously mentioned, for a corrugated roller passing over a corrugated bottom.

Whether the treatment in the churn is continuous or intermittent, the solvent soon becomes charged with resin from which it must be separated by distillation. A still has been designed for this purpose by Chute<sup>20</sup> with the special purpose of preventing foaming, which would carry some of the resin into the distillate. It is a combination of a chambered column still, provided at its base with a quieting and settling chamber which is connected to a sort of boiler through a large tube. Vapor from the boiler enters the settling chamber near the top.

Chute<sup>21</sup> has worked out a process which is especially suitable for his mixed resin solvent, i.e., acetone with ethyl or methyl acetate. The apparatus comprises a series of extractors provided with means of heating and mastication. The solvent is admitted to the extractors on the counter current principle, with a view to treating the rubber in each at least four times or more. The process permits the treatment direct of crude rubbers without drying, since it has been found cheaper to remove the moisture by use of solvents than by drying in the ordinary way. Price calculations on Guayule and Pontianack have been previously discussed.

(To be Continued)

## Chemists to Discuss War Necessities

Coincident with the Fourth National Exposition of Chemical Industries to be held in Grand Central Palace, New York City, during the week of Sept. 23 will be held various conventions of chemical and technical organizations. The meeting and programs will reflect the strides made by the chemists of America during the past year. The exposition also will show the people of the country the remarkable expansion which the chemical industry has undergone, as it will be necessary to use four floors of the building for the exhibits.

The exposition is a war-time necessity; and regarding it as such each exhibitor is planning his exhibit so that it will be of the greatest benefit to the country through the men who visit it, all of whom are bent upon a serious purpose—that of producing war materials in large quantities, and constantly increasing this production till the war has been won by the United States and its allies.

Papers covering practically every phase of chemistry and a discussion of steps that will need to be taken after the war will be presented by leading experts in each branch. Pressing chemical problems concerning many of the chief articles of domestic and foreign commerce will be taken up during the convention, and it is expected that these discussions will have an important bearing on the future manufacture of materials that have been scarce and high-priced ever since the curtailment of American commerce with Germany and other European countries. In order to fill the demands for chemicals hundreds of factories have sprung up in various parts of the country, and while doing a large business, it is pointed out by experts that there is a lack of preparation to meet new conditions which are bound to follow at the close of the war.

<sup>15</sup>U. S. Pat. 815,616 and 890,217, 1907 and 1908.

<sup>16</sup>H. O. Chute, *India R. World*, June, 1909, and July, 1911.

<sup>19</sup>U. S. Pat. 896,434, issued Aug. 18, 1908.

<sup>20</sup>U. S. Pat. 890,216, issued 1908.

## The Human Element in the Mill

Influence of Competition on Process Control Records—Importance of Automatic Recorders and Working Diagrams—Creation of Research Initiative

MANY important ideas of vital interest to mill executives were brought out in the opening address by HUGH K. MOORE at the tenth annual meeting of the American Institute of Chemical Engineers. Mr. Moore spoke of the relation between manager and employee. The following extracts are printed verbatim from the address which will be published in full by the society in the 1918 annual.

### IMPORTANCE OF MENTAL CONTACT BETWEEN MANAGER AND MEN

If you only know what the men think you may be able to make explanations which will enlighten them and give them a different outlook on life. The closer the personal touch between the employer and employee the less is the chance for misunderstandings and the better for both employer and employee.

Do you realize that a man may put down figures which he knows are not the truth and yet never have it enter his mind that he is sophisticating his results? This is not dishonesty because he does not perceive there is any dishonesty in what he has done.

An example of this may be taken from our 1908 records. The operation is burning sulphur with air with the intent of getting the highest possible percentage of sulphur dioxide in the resulting gas. The records on our books show the following results as obtained from hand-fired flat burners used at that time.

| PER CENT SULPHUR DIOXIDE GAS |                  |                 |  |
|------------------------------|------------------|-----------------|--|
| Shift 12 N. to 8 A.M.        | 8 A.M. to 4 P.M. | 4 P.M. to 12 N. |  |
| 15.8                         | 15.6             | 16.5            |  |
| 15.0                         | 18.4             | 14.6            |  |
| 16.6                         | 16.3             | 11.6            |  |
| 15.8                         | 13.9             | 17.3            |  |
| 15.8                         | 16.3             | 16.6            |  |
| 15.8                         | 15.3             | 17.3            |  |
| 15.8                         | 16.2             | 17.2            |  |
| 15.0                         | 17.2             | 16.1            |  |
| 14.0                         | 12.6             | 16.4            |  |
| 16.4                         | 15.3             | ...             |  |
| Average 15.6                 | 15.7             | 15.9            |  |

You will see from the above that there is not very much difference between the maximum and minimum readings.

To show that the above is not a true statement of facts, I submit Chart I giving the analyses from a recording machine. It will be observed that the figures given in the above table are only the maximum figures. You see every time the burner doors were opened the large influx of air weakened the gas. Now every foreman soon found out that after a certain time had elapsed after firing, the gas would test a maximum and not sublime sulphur. He always planned then to be on hand at this time to test his gas and actually put down the figures he found by analysis. This in all probability started from one foreman doing this and when the other foremen did not get equally good results they copied the same method. Now these men were not scientifically trained, and when they averaged up their selected results there was no thought in their minds that they were

of no value whatever. Furthermore the management, on going into the mill and seeing the foreman write down the selected results which he could see were actually obtained on the Orsat, had no suspicion as to how far they were incorrect. Had he known what the men were thinking about he would have been "put wise," and would not have accumulated on his books an amount of data which was absolutely valueless. At this time we had installed an automatic recorder. The recorder record of the same shifts shows far different results though the maximum results are approximately the same. Comparing the two we get results as follows:

| PER CENT SULPHUR DIOXIDE |         |          |
|--------------------------|---------|----------|
|                          | Foreman | Recorder |
| Shifts 8 a.m.—4 p.m.     | 15.7    | 11.5     |
| Shift 4 p.m.—12 n.       | 15.9    | 13.1     |
| Shift 12 n.—8 a.m.       | 15.6    | 12.9     |

Incidentally this illustration shows the value of an automatic machine which records at given definite intervals. Even had the management known of these variations it would have been unable to time the analyses of the different foremen periodically so as to get true concordant results. In the case above (which is given not as an isolated case but as an example of a type) we have an illustration of ignorance, combined with the idea to make as good a showing as possible based on the more or less ever present feeling of self-preservation. Where the superficial observer would have classed the foreman as dishonest the careful observer cannot overlook the psychology involved. It sometimes happens that the management expects too much of the men. By this I do not mean to state that he does so purposely; in fact, he is unaware that he is expecting too much. He probably does not know the complexity of the problem involved and what is more even if he were on intimate terms with his employees he could hardly find it out as they do not know themselves just what is involved and cannot make it clear to their employers. Here is where the chemist or chemical engineer comes in. He, however, should be democratic, of sterling character, and in full sympathy with his fellow beings. He can then obtain from them what information they can impart and with his more technical knowledge reject that which is bad and adopt that which is good. Above all he should not be a man, "who knows it all." The man who goes around with the air of "I know it all" engenders antagonisms and often contempt and discourages suggestions. He may defeat by this attitude the main object of accomplishment which is his task.

The man constantly with a process or apparatus finds out many details of operation which one who is not constantly in touch with it (no matter how able he is) will hardly find out at all. In my experience in mill work I have never run across a man operating a process or device that could not show me valuable points. A lot of opposition to changes which the man-



agement wishes to make may be traced to the fact that the management has not taken care to collect the valuable data which their employees have. They consequently do not know what their men are thinking.

As an illustration I know of a manager who, noticing that knots and bark sank while chips of clear wood floated, designed a process for their separation by flotation. He told the foreman of his scheme who promptly told the manager it would not work, at least not to such an extent as to make it practicable. The manager, an educated man, thinking it was the ever-recurring opposition to innovations, turned on his heel and left the foreman without asking for an explanation. He constructed his machine, installed it, and tried to operate it, and on finding that it would not work finally destroyed it. Later he called the foreman and asked him how he knew it would not work. The

sum of these is also plotted. By plotting in this manner we can illustrate our point and yet simplify the matter to such an extent that it is readily understandable to those who have not, so to speak, made a profession of the study of numerous and complex graphs.

The efficiency curve is the only one known to the foremen and the dotted lines were known only to the investigators. Smith, Brown and Jones are fictitious names.

To the foremen the efficiency meant the amount of water evaporated per pound of coal and this was arrived at by metering the water into the boiler and dividing the same by the pounds of coal used.

It will be seen from the above chart that Smith was an honest man and the amount of heat accounted for did not ever get to an amount over 100 per cent of the heat in the coal that could be accounted for,

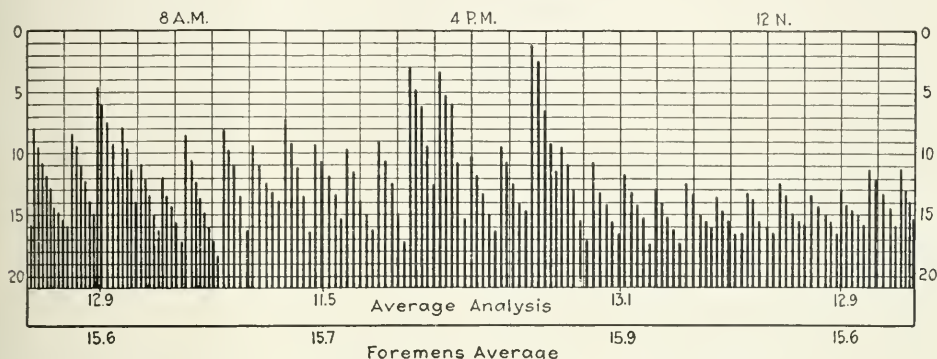


CHART 1—ANALYSIS OF RESULTS FROM A RECORDING MACHINE

foreman took a piece of wood floating in the wood-room tank and cut many chips from the same. They, when thrown into the water, went to the bottom. This foreman from his daily work had observed certain facts which had escaped the attention of the manager. This manager made the mistake of underestimating the intelligence of his foreman. Some see and remember the minutest details, while others may miss these entirely and pay attention only to the principles involved. The strict observance or non-observance of detail is often, in fact is generally, the difference between success and failure, provided your basic principle is sound.

In the illustration before given we have shown a typical case wherein men put down results which they knew did not represent the facts and were entirely honest in what they were doing.

I am now going to give a typical example of wilful sophistication and will illustrate it by Chart 2 which shows more or less accurately the efficiency of the foremen on each shift in the boiler house. This chart is only illustrative, for in order to save space and in the interest of lucidity it is condensed in time and all the factors are not plotted; radiation, convection, the necessary blowage, etc., are not plotted but lumped together in a constant called radiation 5 per cent.

The stack losses and the ash losses and the efficiency of the boiler are plotted all in terms of the percentage of B.t.u. contained therein of the original coal, and the

save by errors in observation and calculation. On the fourteenth and fifteenth day Jones probably, by accident rather than design, blew off more water than was customary. On the sixteenth and seventeenth he ran normally and probably cogitated on the fact of his high efficiency. In his cogitations it occurred to him that he had blown an unusually large quantity of water when he obtained a high efficiency and from then on Jones purposely blew an ever-increasing amount of water through the blow-off.

Brown also had been cogitating over the high efficiency of Jones and finally gets wise but he overdoes it and his efficiency jumps to 86 per cent. Now the graphic department in plotting all the curves noticed that the total B.t.u. accounted for reached as high as 110 per cent of the B.t.u. in the coal. They report it to the chemical engineer and he sees where the plant is not complete and perhaps he talks with Smith. At any rate, on the twenty-seventh he installs a tank capable of standing the full pressure of the boiler and pipes the blow-offs of the boiler to this tank. By this means certain deductions can be made and the efficiency as figured from the input of water to the boiler is corrected. It will be observed that the efficiency of both Brown and Jones dropped while that of Smith did not change upon installing the tank.

I have given an example of the management underestimating the intelligence and powers of observation of the employees. To underestimate the difficulties

encountered by the men, while perhaps not of as great importance as the foregoing is still of sufficient importance to warrant its mention.

#### WORKING DIAGRAMS

In all probability most chemical and metallurgical operations are carried on by men who have had no training in chemistry or metallurgy. By long experience a man may obtain a technique which will enable him to carry on an operation successfully even though it may be complicated by many variables. Now if these men are organized they may, if they so desire, exert a pressure on the mill management all out of proportion to their numbers. This is especially true if the operation they control is a fundamental part of the operation of the plant. I have seen the time when six men not only had the power but exerted it to shut down the largest mill of its kind in the world. Realizing this fact, they made most exorbitant and

pressure. When we first started this system we found it very difficult to make the men understand that a pressure below atmospheric pressure was a real pressure, so we plot those pressures below atmospheric pressure as minus pressures, and a table of the pressures corresponding to temperatures of steam is given to every cook. Thus, 158° F. would show as pressure on this chart as -10 pounds while 250° F. would show as +15 pounds. Now the gage pressure<sup>1</sup> is plotted and the steam pressure<sup>2</sup> corresponding to the temperature is also plotted. The difference between these two is the gas pressure which is also plotted. Then inasmuch as it is the SO<sub>2</sub> gas which does the cooking this picture shows the cook if he is blowing off his gas too fast. The crosses on the chart are given in place of figures for the reason that we are dealing in principles and it is not our object to give away private information of the mill. The cooks are taught to plot these charts themselves and in so doing they correct their cooking procedure. Having established the value of the chart we at once placed ourselves in a position to demand uniformity of results. This example is an illustration of how the management formerly expected too much of the men, when they asked for greater uniformity of results than they got.

This chart has another value in that it is now possible to do experimental work in the laboratory and draw the desired chart which we may reasonably expect the cooks to duplicate in practice.

#### CREATING TECHNICAL INITIATIVE

There is a great tendency in manufacturing plants to hide the light of employees under a dark bushel basket. This is a narrow and shortsighted policy and while the management may save a few dollars in salary the intangible loss far outweighs the small amount saved.

As an illustration of what I mean I may give the policy of our own research laboratory as compared with the general attitude of laboratories over the country. When we hire a man we try to impress upon him that in considering his compensation he should not consider his salary as his total compensation. The reputation which he is enabled to make is as much a part of his compensation as his salary. We do not stand in the way of a man obtaining a wide reputation; we even aid him to get the same. This not only gives him an idea of what he is worth by enabling him to receive offers from the outside world which he otherwise would not have received, but it also informs the management that if he is worth so much to an outside organization he is worth as much or more to our organization. You will say, "I can see how this benefits the employee, but how does any such policy benefit the mill?" The answer is that such a policy tends to produce what I may term the Stimulation of the Initiative. And above all this policy tends to create respect and con-

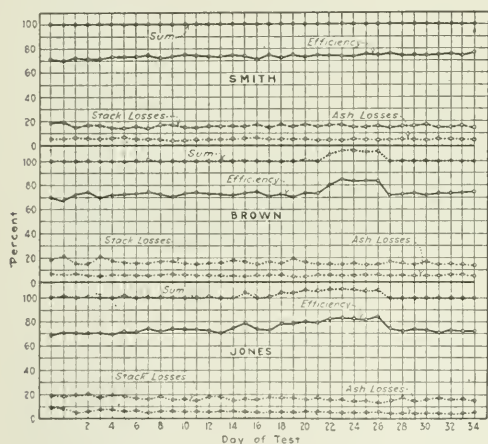


CHART 2—BOILER PERFORMANCE CURVES FOR THREE FOREMEN

unscrupulous demands. Here again had the management possessed the information which the men had obtained, this thing would have been impossible. Now here is an operation containing many variables with the possibilities of spoiling a cook far in excess of the possibilities of making a cook, and with so many variables the probabilities are that though they may get by on making the cook, the products of separate cooks are not uniform but may vary greatly. Now if you want a carpenter to make a house you do not cut all his lumber for him and tell him "Everything is ready, now build your house." The carpenter would tell you to give him the picture or plans of the house and he could cut the lumber himself.

In the same way the operator of a complex chemical operation would like if it is possible to obtain a picture or plan of this operation. The more complex the operation the more ingenuity must be exercised to obtain a picture which means something. As an illustration, Chart 3 shows an actual digester cooked in 1911. On this chart the ordinates are pressures and the abscissæ are time in hours. The three pressures plotted are gage pressure, steam pressure and gas

<sup>1</sup>It will be observed that the steam pressure and gage pressure are on a different scale from the gas pressure and to this extent the chart is deceptive to the eye. To make these on the same scale the gage pressure and steam pressure should be 14.7 pounds higher.

<sup>2</sup>Just how this came to be plotted this way I do not know. However, the gas pressure is correct, which, of course, is the main thing. The cooks have formed the habit of making charts this way and as a change of chart to a more scientific scale would not in the end enable them to make better cooks and would during the process of changing tend to have them make worse cooks it has not been thought advisable to make the change.

fidence which are the foundation stones for loyalty and good service. We find first that the policy outlined not only informs the employer what he is worth but it informs the employee. It is very natural that an employee should get an exaggerated idea of his own importance. If, however, he finds that others besides his employer do not accept him at his own valuation he will modify his ideas. He can no longer take the attitude that if he could get out into a wider world that he would be more appreciated.

His reputation is what he makes himself and he receives full value according as he makes his reputation. Having now obtained a more or less true estimate of his own value he immediately starts to build up for himself a reputation and this can only be done by rendering valuable service. Here then may be a starting point for the development of the initiative. But it is not sporadic attempts which cause development; it is the constantly exerted force of the will which must be applied to allow physical growth to take place with the consequent mental growth. A dissatisfied employee will never exert the constant effort of the will to develop, even though it be in his own interest as well as his employer's. As an example of the application of the following principles I wish to state that in one of our mills our chemists began to develop the much-desired initiative. I was called away and was constantly out of touch with these men for four years and did not see much of them for two years more. During this time the man to whom they were directly accountable also tried to develop in these men the personal initiative, but defeated his own purposes by not giving the men the credit which was theirs.

Instead of taking out joint patents with these men he took them out in his own name, and while he talked and lectured on mill organization he never gave due credit to those who helped in this work, and while as a rule he did not claim directly all credit for this work, he nevertheless got the entire credit by implication. The result of this procedure was the entire destruction of the incentive, which stopped the development of the initiative. During this entire time there is no credit to this concern for patents taken out by these men, neither so far as my knowledge goes are there any publications by which these men could receive due credit from business men and others in their profession for that which they had accomplished. It is our problem to make conditions such as to recreate as far as possible the lost initiative. This is a far more difficult problem than formerly because the nerve tissues are less plastic and less susceptible of change by excitation than was their condition eight years ago. In the formation of habit it is essential as far as possible to avoid misdirected habit which becomes more or less of a stumbling block. Right here I wish to state that it is a great mistake to put a man in charge of the execution of a problem on which he has formed the preconceived opinion that its successful solution will be impossible. The successful solution of a problem may or may not be possible, but if you have determined to try and solve this problem after hearing all arguments pro and con, then the way to start is to put its execution in charge of a man who is an optimist as far as this particular problem is concerned. Here again we have an illustration of habit.

Every failure of the man who believes this cannot be done, and there will be many, will only tend to confirm him in his preconceived belief that it cannot be done, and repeated failures simply stimulate the habit of unbelief as far as this problem is concerned. We have seen a very good illustration of this principle in the

1907 MILL COOKING REPORT

| Cook No. 56       | Hrs. after Steaming | Time  | Tem- perature | Gauge Pressure | Steam Pressure | Gas Pressure | Percent SO <sub>2</sub> |
|-------------------|---------------------|-------|---------------|----------------|----------------|--------------|-------------------------|
| Digester No. 6    | 0                   | 6     |               |                |                |              | XXX                     |
| Date, 1907        | 1                   | 6.30  |               |                |                |              | XXX                     |
| Filling Time xxx  | 1                   | 7     | 145           | 10             | -11.3          | 21.3         | XXX                     |
| Steamed at 6 a.m. | 1 1/2               | 7.30  | 151           | 14             | -10.8          | 24.8         | XXX                     |
| Blown at 4 p.m.   | 2                   | 8     | 157           | 19             | -10.3          | 29.3         | XXX                     |
| Hours Cooked 10   | 2 1/2               | 8.30  | 101           | 28             | -10.           | 38.0         | XXX                     |
| Steamed by xxx    | 3                   | 9     | 179           | 38             | -9             | 47.0         | XXX                     |
| Blown by xxx      | 3 1/2               | 9.30  | 199           | 68             | -6             | 74.0         | XXX                     |
| Blowing Test xxx  | 4                   | 10    | 195           | 71             | -5             | 82.0         | XXX                     |
| Acid Temp. xxx    | 4 1/2               | 10.30 | 207           | 62             | -              | 64.0         | XXX                     |
| Test: Total xxx   | 5                   | 11    | 240           | 67             | 13             | 54.0         | XXX                     |
| Free xxx          | 6                   | 12    | 272           | 71             | 20             | 42.0         | XXX                     |
| Comb. xxx         | 7 1/2               | 1.15  | 299           | 72             | 52             | 20.0         | XXX                     |
|                   | 8                   | 2     | 315           | 72             | 60             | 3.0          | XXX                     |
|                   | 9                   | 3     | 321           | 78             | 75             | 3.0          | XXX                     |
|                   | 10                  | 4     | 318           | 78             | 72             | 6.0          | XXX                     |
|                   | 11                  | 5     |               |                |                |              | XXX                     |
|                   | 12                  |       |               |                |                |              | XXX                     |

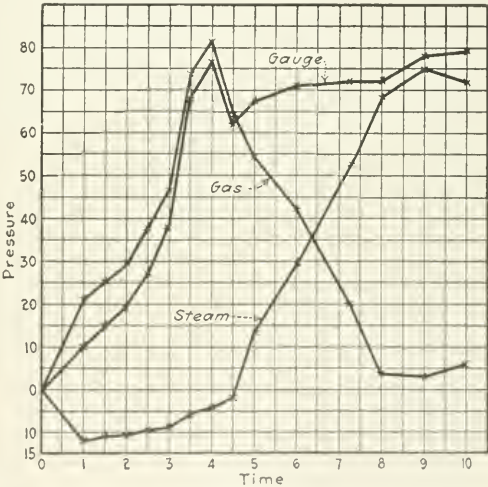


CHART 3

last three years. We had such a problem and the superintendent of one of our mills put a man of marked ability in charge of its execution. The marked ability of this man was recognized by the government sending him to France, putting him on General Pershing's staff as a chemical engineer with the rank of captain. Nevertheless he was a pessimist as far as this problem was concerned and nothing but discouraging results were forthcoming. When he left, the solution of this problem was sought by the same staff with the exception of this man and solved with the greatest success. The remark which he made upon being told of the successful solution of the problem, viz.: "I am from Missouri, you will have to show me," illustrates his mental attitude as far as this problem is concerned.



Now when you realize that mental growth is the product of constant application of the mind, you will readily see that the management, if it gives up a problem too soon, before opportunity for mental development has had a chance to take place, makes a great mistake.

I worked on one problem off and on for seven years; on another problem I worked three years and on the one just mentioned over three years. Two is a short time to solve a real big problem. Now from what has been said it will be seen that the changing of an executive in charge of a problem, unless he proves himself radically unfit, simply because he does not arrive at the solution immediately is a grave mistake. The executive has this problem before him night and day and the constant excitation of this part of his brain is producing a slow but nevertheless sure development which, if the problem is not impossible, must lead in time to its solution. Now if constant changes are made among the men in charge the new man has to go through all his predecessor went through before he has reached the same mental development. If then other changes are made the foregoing is repeated and the management has nothing to its credit but a large experimental expense. The management should be careful in choosing the man who is put in charge, but having chosen a man it should continue this man on this problem until results are achieved or until it has made up its mind that a successful solution will not pay dividends on the amount of money required for its solution. As mills go, far too many problems are abandoned before a fair trial has been given, owing to the non-observance of these principles.

I have spoken here of the mental attitude of the executive in charge of the successful solution of a problem, and laid down the principle that he should be a believer in its successful solution from the start, and now I want to say one word as to the attitude of the management in regard to suggestions coming from those responsible to it. It must be constantly borne in mind that the management puts its capital in these operations and that it will suffer for all mistakes it makes as well as the mistakes of its employees and that consequently its decision should be final, good or bad. But it often happens that it can reap benefit from the mistakes it makes as well as penalties. The wise management will allow certain leeway (within certain limits) to its chief executives as they, after all, carry out the policy of the management.

For instance, a foreman may come to the executive with a proposition which that executive knows from past experience will not work. He may turn it down absolutely or he may consider after figuring it over that he will allow the foreman to try it and fail and convince himself. I have done this many times myself and have obtained results from the changed mental attitude of the men which far outweighed the small expense involved and sometimes I have seen how to make suggestions from the failure which may change the failure into more or less of a success. In case of foreordained failure, so to speak, I always put it up to the man himself and give him my heartiest support so that when it fails he can have no comeback. If, as sometimes happens, the management is mistaken and the man gets the solution, the executive should not be

grudging of his acknowledgement, but take off his hat to him, so to speak, in a wholehearted manner. This tends to produce not only co-ordination but co-operation and the *esprit de corps* which we are striving to obtain.

## Gases Used in Warfare

In an article by Major S. J. M. AULD, entitled, "Methods of Gas Warfare," published in the *Journal of the Washington Academy of Sciences*, Feb. 4, 1918, the following list of gases is given as being used by the Germans in the present war.

1. Allyl isothiocyanate (allyl mustard oil)  $C_3H_5NCS$  (shell).
2. Benzyl bromide,  $C_6H_5CH_2Br$  (shell).
3. Bromoacetone,  $CH_3Br.CO.CH_3$  (hand grenades).
4. Bromated methyl ethyl ketone (bromketone),  $CH_3Br.CO.C_2H_5$  or  $CH_3.CO.CHBr.CH_3$  (shell). Dibromketone,  $CH_3.CO.CHBr.CH_2Br$  (shell).
5. Bromine,  $Br_2$  (hand grenades).
6. Chloroacetone,  $CH_3Cl.CO.CH_3$  (hand grenades).
7. Chlorine,  $Cl_2$  (cloud).
8. Chloromethyl chloroformate (palite),  $ClCOOCH_2Cl$  (shell).
9. Nitrotrichloromethane (chloropicrin or nitrochloroform),  $CCl_3NO_2$  (shell).
10. Chlorosulphonic acid,  $SO_2Cl.OH$  (hand grenades and "smoke pots").
11. Dichlorodiethylsulphide (mustard gas),  $(CH_2ClCH_2)_2S$  (shell).
12. Dimethyl sulphate,  $(CH_3)_2SO_4$  (hand grenades).
13. Diphenylchlorarsine,  $(C_6H_5)_2AsCl$  (shell).
14. Dichloromethyl ether,  $(CH_2Cl)_2$  (shell).
15. Methylchlorosulphonate,  $CH_3ClSO_3$  (hand grenades).
16. Phenylcarbylamine chloride,  $C_6H_5.NCCl_2$  (shell).
17. Phosgene (carbonyl chloride),  $COCl_2$  (cloud and shell).
18. Sulphur trioxide,  $SO_3$  (hand grenades and shell).
19. Trichloromethylchloroformate (diphosgene, superpalite),  $ClCOCCl_3$  (shell).
20. Xylol bromide (tolyl bromide),  $CH_3.C_6H_4.CH_2Br$  (shell).

## Rulings on Importation of Magnesite and Manganese

The War Trade Board has amended the restriction upon the importation of magnesite to permit its importation, under the back-haul proviso, when shipped as return cargo from Europe and the Mediterranean coast of Africa, and when shipped from convenient ports where loading can be done without delay.

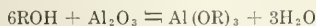
Importations of manganese ore from Asia and Australasia have, by another ruling, been prohibited as to ocean shipments made on and after July 20, 1918; and, to make this ruling effective, all outstanding licenses for the importation of manganese from those countries have been revoked as to ocean shipment on and after July 20, 1918.

Adequate supplies can be obtained, it has been found, from sources near by, entailing far less strain upon the tonnage resources of the United States during the present difficult period than shipments from the distant ports in Asia and Australasia.

## Synopsis of Recent Chemical and Metallurgical Literature

**Molybdenum Steel.**—Discussing Dr. H. M. Howe's recent A. I. M. E. paper on "The Erosion of Guns", Mr. H. R. BATCHELLER said that ten years ago it would have been hard to determine molybdenum in steels containing considerable amounts of nickel and chromium. "A 1907 analysis of ferro-molybdenum by commercial methods gave what purported to be the following results: iron 92.55; carbon 5.64; molybdenum, trace. It subsequently developed that the 'carbon' was mostly molybdenum. The consulting chemist was C. T. Hennig, a former employee of Krupp, who represented them in this country in certain technical ways with special relation to molybdenum, chromium and manganese. The firm producing this ferro-molybdenum was offered a contract for the sale of its whole production to Krupp, who used it for ordnance purposes and would have been glad to get more. According to Hennig, the physical properties of the steel were improved by the addition of molybdenum just before pouring; he also said that analysis would often show only a trace of molybdenum in the steel, while the slag would be high and some molybdenum would be volatilized, especially if the molybdenum were added in the form of metal and not as ferro-molybdenum. When using the metal, it was, therefore, necessary to protect it from oxidation by plating, and silver plating was used successfully."

**Corrosion of Aluminium.**—At a meeting of the Society of Chemical Industry in London, Messrs. RICHARD SELIGMAN and PERCY WILLIAMS gave an account of the reaction between aluminium and anhydrous organic hydroxyl compounds such as the fatty acids, phenols and alcohols. The effective protection from corrosion afforded by the thin coherent coating of  $Al_2O_3$  on the aluminium is what makes this very reactive substance an industrially useful metal. As would be expected upon considering the reactions,



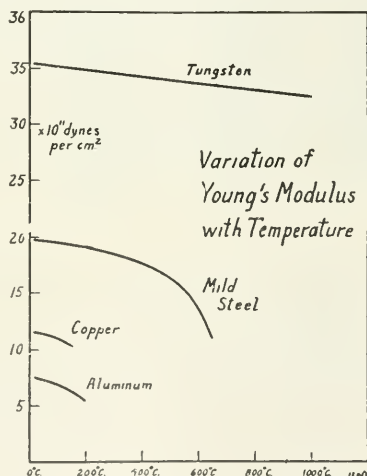
from the point of view of mass action, both of these would go to the right, were they initially started by decreasing the  $H_2O$  content to a sufficiently low point. Attention was brought to the subject by the failure of aluminium to resist corrosion in phenol concentrating distilling equipment. Some use can be made of this reaction for producing aluminium oleate, stearate, etc., as these acids, when anhydrous, react immediately with aluminium.

**Corrosion of Lead.**—In the discussion of the corrosion of lead before The Society of Chemical Industry<sup>1</sup> the fact was brought out that the sheet lead of old London roofs had decomposed where they were in contact with oak or portland cement. Condensation of moisture with wood acids and  $CO_2$  produced re-

sults similar to the Dutch White lead process in the former case. In the latter, sufficient alkaline salts are present to change the metallic lead to plumbites and plumbates. At the present time, sheet lead for chemical work has from 6 to 10 per cent antimony alloyed with it to increase stiffness to prevent creeping. In acid work, fluorine and silica must be prevented from being present, since hydrofluosilicic acid violently attacks lead.

**Aluminium in Germany.**—Low grade alumina ores are reported as being refined at the Neuhausen Works by means of the Moschicki process, by which producer gas is used as a reducing agent with the formation of aluminium nitride. Upon hydrolyzing, pure alumina and ammonia are obtained as in the Sepek synthetic ammonia process. The alumina is then reduced in an electric furnace as usual. Perhaps some such process can be used for obtaining alumina from certain clays, such as halloysite, which is abundant in the United States, and, according to Mellor, decomposes into alumina and silica at 350 degrees Centigrade.

**Variation of Young's Modulus with Temperatures.**—H. L. DODGE has presented four papers in *The Physical Review*, second series, Vol. 2, p. 431; Vol. 5, p. 373; Vol. 6, p. 312; and Vol. 11, p. 311, on the relation existing between temperature and elasticity of copper, mild steel,



aluminium and drawn tungsten, respectively. In the last paper he describes a new electrically-heated tube furnace for the work whose construction approximates that of a black-body. The wire under test is observed through mica windows in the furnace wall. Preliminary experimentation consisted of measuring the coefficient of expansion (found to be 0.00000456 per degree C.) In measuring the modulus of elasticity, the wire was uniformly heated from end to end by the passage of a constant electric current, and the temperature determined by its thermal expansion. The value of Young's modulus at 20 deg. C. ( $35.5 \times 10^{11}$  dynes per square centimeter) is lower than that given by Fink, but it is probable that tungsten wires prepared by different workmen differ that much in physical properties. The figure collects the results of all four metals graphically.

<sup>1</sup>Journal of the Society of Chemical Industry, Vol. XXVII, No. 11, Pp. T. 159-165, June 15, 1918.

<sup>2</sup>Journal of the Society of Chemical Industry, Vol. XXXVII, No. 3, p. T. 33, Feb. 15, 1918.

## Recent Chemical and Metallurgical Patents

**Distillation of Wood Tar.**—ROBERT C. PALMER, of Pensacola, Florida, patents the process of adding to wood tar a suitable amount of water and chemical catalyzer such as phosphoric acid, and distilling the mixture, whereat the complex combinations of phenyl, methoxyl, etc. radicals are hydrolysed to methyl alcohol and acid phenol, condensing the vapors and recovering a better yield of alcohol, acetic acid, phenols and tar oils. (Assigned to the public; 1,271,071. July 2, 1918)

**Manufacture of Alkali and Organic Chlorides.**—K. P. McELROY, of Washington, D. C., patents a process for the simultaneous manufacture of alkali and organic chlorides. A tank 20 (Fig. 1) is subdivided by diaphragms so as to make a succession of chambers containing anodes A of crushed carbon, cathodes C of wire mesh, and between each pair an electrolyte of brine. The electrolytic compartments are made

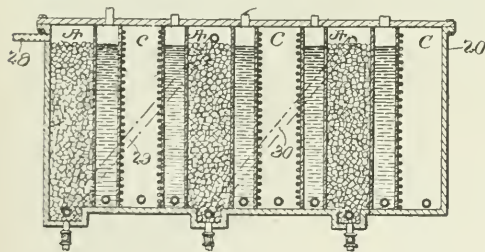


FIG. 1

narrow especially to diminish energy losses in overcoming the resistance. Furthermore, the polarization effect of the chlorine collecting on the anode is continuously neutralized by leading purified oil gas successively through the anode chambers by pipes 28, 29, 30 and 31. The olefins on contact with chlorine may react in either of two ways. One is a direct combination with it to form olefin chlorides, ethylene,  $C_2H_4$ , thus gives ethylene chloride, or "Dutch liquid,"  $(C_2H_4Cl_2)$ , a heavy oily body insoluble in water and having an odor and many other properties resembling those of chloroform. The other reaction is one in which water takes part and a chlorhydrin, or chlorinated alcohol, is produced. A molecule of chlorine,  $Cl_2$ , reacts with  $HOH$  and  $C_nH_m$ , to produce  $HCl$  and  $C_nH_mOHCl$ , or a chlorhydrin. The actual reactions at the anode vary with conditions; with a high current density chlorine may form as a gas. With an ample amount of water vapor chlorhydrins are formed. The recovery and separation of the separate products also depends upon the degree of formation and the use to which the product is to be put. (Assigned to Chemical Development Co., 1,264,536; Apr. 30, 1918.)

**Process of Making Exchange Bodies.**—GEORGE RUDOLF of London, Eng., notes that many natural silicates contain more or less zeolite which is a very active "exchange body." These minerals are very

useful in purifying water; an exchange takes place between the calcium and magnesium compounds of the water and the alkali of the silicate, the latter going into solution as harmless alkali compounds while lime and magnesia remain in the zeolite. After a sufficient period of use the exchange silicate is revived by treatment with a solution of common salt ( $NaCl$ ); sodium now enters the silicate, while calcium and magnesium are given up to the salt solution as chlorides. The inventor finds that if these igneous rocks (such as trass) be pulverized and boiled with 10 per cent hydrochloric acid, a certain portion of these complex exchange silicates goes into solution. After filtering and washing, the residue is boiled for several hours in a ten per cent solution of alkaline carbonate, to which a small amount of caustic soda has been added. This extract is then mixed with the acid solution, the gelatinous precipitate filter-pressed, and the cake dried at about 70 deg. C. On throwing this cake into water it breaks up into hard, angular grains, which after centrifuging, are found to contain the "exchange" properties of the original trass in a very marked degree. (Assigned to the Permutit Co., 1,263,706; Apr. 23, 1918.) Lemberg pointed out in 1876 that gelatinous exchange bodies could be produced from solutions of alkaline aluminates and alkaline silicates. Previous attempts to convert this gelatinous mass into clinker-like, strong and pervious substances have failed because the precipitate always contained a considerable excess quantity of alkaline mother liquor. The present inventor finds that it is only necessary to mix two solutions of two hydroxides of more or less amphoteric properties together, one such solution being alkaline in reaction and the other being neutral or acid. The word neutral means containing an amount of acid component chemically equivalent to the metal functioning as a base, such, for instance, as aluminium sulphate. As a particular case, if a solution of aluminium sulphate is mixed with a solution of commercial water glass in such proportions that the final mixture shall be neutral to phenolphthalein, a precipitate appears. If this precipitate is filter pressed, dried and granulated as above, it will be found to have "exchange" properties. (Assigned to Permutit Co., 1,263,707; Apr. 23, 1918.)

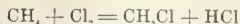
**Apparatus for Manufacturing Chlormethane.**—Patents No. 1,111,842 and 1,190,659 cover the method of mixing chlorine with a large excess of methane in the cold and then passing the mixture into a heated reaction vessel. Two objects are then attained, namely, a smooth reaction free from carbonization, and a product which consists chiefly of monochlormethane. The chlorination vessel if made of silica or brick is hard to make tight, while on the other hand, most metals are attacked by hot chlorine or catalyze the reaction



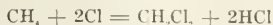
The inventor has therefore devised a furnace shown in Fig. 2 consisting essentially of a tight iron tank 1 lined with silica brick 2, with a packing of powdered flint 3 between the two. The cold chlorine entering through pipe 16 is mixed with about five times its volume of cold methane coming through valve 20 in the tee 15. Ten volumes of methane are heated in furnace 17 to about 370 deg. C., and the two gas



streams unite in the silica tube 9 and enter the reaction chamber at a temperature of about 250 deg. C. The reaction



together with a small amount of the reaction



goes forward smoothly without the production of carbon and hydrochloric acid until the gases issuing through 22 contain less than 0.01 per cent of uncombined chlorine. The temperature of the chamber is maintained by the heat evolved by the chemical reaction itself to a temperature of from 400 to 500

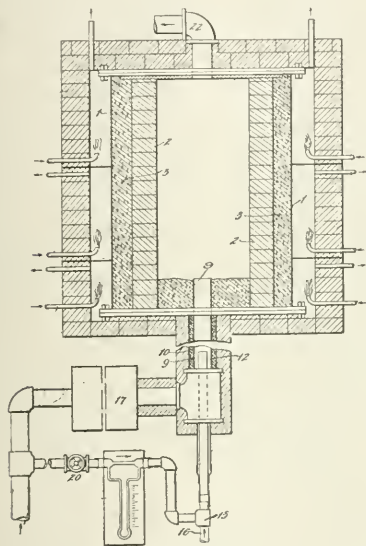


FIG. 2

deg. C., and it is only necessary to heat the external iron shell 1 sufficiently that excessive radiation may not cool the contents. Any chlorine gas which percolates outward is changed to hydrochloric acid by contact with the powdered flint before reaching the shell, and consequently rendered incapable of corroding the steel. If pure chlorine enters hot methane as through pipe 12 a chlorine flame produces carbon black and hydrochloric acid only. Dilution as above noted is necessary and the temperature control is very easily had by merely regulating the amount of methane bypassing the furnace 17. (Assigned to Roessler & Hasslacher Chemical Co., 1,263,906; Apr. 23, 1918).

**Side Blown Converter Process.**—JOHN H. HALL, of New York City, (assigned to Taylor-Wharton Iron and Steel Co.), notes that in blowing metal containing say 2 per cent silicon and 0.5 per cent manganese in a side blown converter, the blast impinging on the surface layers will oxidize the various impurities in what amounts to a thin layer of metal. The silicon and manganese oxides form a slag which absorbs iron oxide until the slag becomes freely fluid, and at the same time the iron oxide contained makes it highly oxidizing. This fluid slag is stirred into the carburized

metal remaining in the lower part of the bath by the air currents, when a violent reaction liberating large quantities of carbon monoxide causes a boiling action to froth the metal and slag up so as to overflow the mouth. After subsidence, the slag is stiff and low in iron oxide, and the cycle starts again. In case the manganese is contained in the metal in a greater relative percentage, the time between boils is correspondingly diminished. The patentee claims the process of making slags as high in manganese (approximately of a composition  $\text{SiO}_2$ , 40% and  $\text{MnO}$  60%) that it produces a freely fluid slag from the first and during the greater part of the operation. This slag does not absorb iron oxide as does another lower in manganese, and any iron oxide formed by the blast is then immediately available as an oxygen carrier to the metalloids, which are thereby eliminated gradually without frothing. The requisite proportions of silicon and manganese are had by melting proper pig irons, scrap steels and ferroalloys in the cupola. (1,249,075; Dec. 4, 1917.)

**Acetyl Cellulose.**—WM. G. LINDSAY, of Newark, N. J., received a patent for a method of producing acetylation of cellulose in varied degrees, in which cellulose fibers are saturated with acetic acid and alcohol, then subjected to dehydrating agents—acetic anhydride, sulphuric acid, benzene, etc.—the resulting fibers being physically unaltered and soluble in acetylene tetrachloride. (1,265,216; May 7, 1918.)

**Alunite from Potash Recovery.**—HOWARD F. CHAPPELL, of New York, N. Y., patents the method of converting the alkali in insoluble alumina of calcined alunite into water-soluble compounds, which comprises washing and filtering the calcined alunite to remove soluble potassium compounds, mixing the filter cake with an alkali and an alkali earth, calcining the mixture at about 900 deg. C., and leaching the water-soluble compounds from the calcine. (1,270,266. June 25, '18.)

**Bauxite.**—WALTER L. MELICK, of Columbus, Ohio, patents the process of heating to its boiling point a mixture of substantially saturated aqueous solution of sodium hydroxide and bauxite ground to a degree of fineness of at least seventy mesh, the mixture having the consistency of a thick paste, adding water frequently to prevent drying out, and finally leaching the sodium aluminate formed (1,271,192. July 2, 1918).

**Rust Prevention.**—WM. H. ALLEN, of Detroit, Mich., notes that when articles of iron or steel are treated with soluble acid phosphates according to the patents to Coslett, No. 870,937, and to Richards, No. 1,069,903, they sometimes rust in very small spots. This is possibly due to the formation of hydrates or other compounds capable of causing rusting. He patents the process of rendering these undesirable compounds of iron inactive by placing the treated article for a short time in an approximately five per cent solution of alkali ferrocyanide. By this treatment the deleterious iron compounds are probably changed to mixtures of ferri and ferrocyanides, which are non-corrodible. (1,260,740; Mar. 26, 1918.)

**Purifying Iron in a Blast Furnace.**—GUSTAV R. GEHRANDT, of Oak Park, Ill., patents the process of

purifying the iron produced in a blast furnace by installing a lower row of tuyeres inclined downwardly and so placed that they deliver a stream of hot air into the metal bath, as shown in Fig. 3. The inventor claims that in this way a purified iron is produced; at the same time a saving in fuel is effected owing to the heat abstracted from the molten metal and that fur-

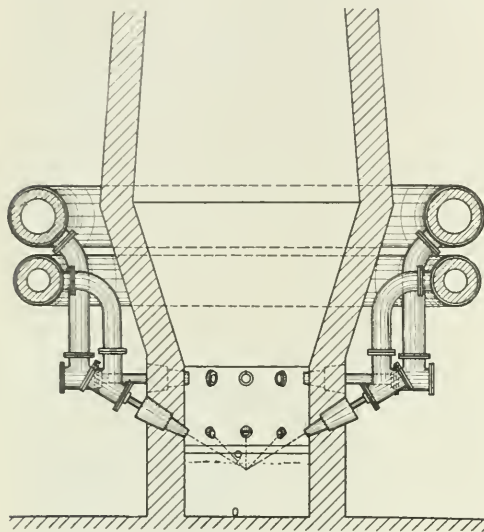


FIG. 3

nished by the purification reactions. The principal agitation is confined to the center of the hearth, leaving a comparatively placid annulus near the walls from which the slag can be drawn without interrupting the refining process. (1,260,660; Mar. 26, 1918.)

**Sponge Iron.**—ALF SINDING-LARSEN, of Norway, patents a process of manufacturing iron sponge from ore wherein the ore is spread in a thin layer over a perforated plate. Heat from an electric resistor is radiated from above through an atmosphere of hydrogen-carrying gas. The water vapor formed by the reaction diffuses quickly, by reason of a great difference in partial pressure, through the ore bed and perforated plate into a lower channel where it is condensed on cooling pipes. In this manner the reduction is more complete, since reoxidation of the iron by moisture is prevented. The ore bed may be carried on a car, whose reciprocating motion works the charge forward with the aid of rabbles fixed in the furnace roof. (1,256,939; Feb. 19, 1918.)

**Annealing Atmosphere.**—FRANK PERRY, of Tipton, England, notes the fact that producer gas used as an atmosphere to prevent scaling or filmlike deposits on metal surfaces during annealing is usually treated in some manner to remove the contained water vapor, unsaturated hydrocarbons, and sulphur compounds. This is not sufficient to prevent all action on bright surfaces, in which case he patents the method of removing saturated hydrocarbons (methane, etc.) by passing the cleaned gas through a tube at 250 deg. C.

containing loose pieces of iron, renewed periodically. (1,261,606; April 2, 1918.)

#### REFRACTORIES

HARRY A. KENNEDY of Clearfield, Pa., proposes to increase the refractivity of silica bricks by carefully screening out and discarding all fine particles of silica before mixing with the finely ground binder of fire clay. In this manner the formation of somewhat fusible silicates between the finely divided and mixed particles of clay and silica is prevented. Bricks subjected to no abrasion can be made of large-sized silica with a minimum amount of binder, while in other cases the expansion of the silica may balance the shrinkage of the clay so as to form a brick of approximately zero temperature coefficient. (1,260,398; Mar. 26, 1918.)

PAUL R. HERSHMAN, of Chicago, has previously patented (No. 1,135,182) the production of refractories capable of withstanding a temperature in excess of 2200 deg. C. These he formed by the use of alumina (preferably from calcined alunite) bonded with carbonaceous material such as glue, hard pitch, and glue-like "tank water" from abattoirs. In heating these pressed refractories he found that they tended to disintegrate during the temperature interval above the decomposition point of the carbonaceous material and below the sintering temperature of the aggregate. He therefore patents the use of a binder such as calcium sulphite which will form compounds holding the mass coherent during this interval, but on further intense heating will be volatilized and thus have no effect upon the ultimate refractivity of the brick. (1,240,569; Assigned to Mineral Products Co., Sept. 18, 1917.)

**Manufacture of Spiegel.**—A. L. CROMLISH, of Sharon, Pa., patents the process of smelting "flush" or "tapping" cinder produced in the open hearth process into a low-manganese, high-phosphorus spiegel which can then be used as a ladle or furnace addition when making steel for subsequent rolling into thin sheets, which steel, as is known, requires a slight addition of phosphorus to prevent sticking when rolling packs of fours and eights in the finishing passes. (1,261,907; Apr. 9, 1918.)

**Ferro Phosphorus.**—H. A. WEBSTER, of Columbia, Tenn., finds that if a proper mixture of iron phosphate, coke and limestone is heated to from 1000 to 1500 deg. C. in a rotary kiln, the interior of the furnace becomes lined with incandescent carbon, which materially hastens the reaction. The products of the reaction—an iron phosphide containing 22 to 25 per cent phosphorus, and a slag—may be granulated and separated by a magnetic separator. The gasified phosphorus may be largely retained in the modular phosphide by charging iron filings or iron ore with the mixture. (1,264,237; April 30, 1918.) The proportion of phosphorus in the compound may be increased to 28 or 30 per cent by heating the above mixture in a closed furnace at two to three atmospheres, cooling the melt under pressure until just molten, and then tapping the contents. (1,264,236; April 30, 1918.)

## Northrup-Ajax High-Frequency Induction Furnace

THE induction furnace described herewith presents features in furnace practice which are radically new in every particular.

All types of induction furnaces heretofore made consist essentially of a step-down transformer. The primary winding of this transformer has many turns on an iron core, and is designed for direct connection to a source of alternating current supply of ordinary or very low frequency. The secondary of this transformer is a closed loop of one turn. The heat developed by the large current which circulates in this single turn is the heat which is utilized. This single turn, usually of molten metal in a trough of refractory material, constitutes a closed electric circuit through which the iron core of the transformer threads.

By employing current of high frequency it becomes unnecessary to use any iron, interlinking with the primary winding and the secondary electric circuit, to obtain the powerful inductive effects which are required to produce efficient heating. The frequency found desirable to use for obtaining good efficiency in the heating is about 20,000 cycles per second. The successful operation of the Northrup-Ajax high-frequency induction furnace is not dependent upon any particular source of supply of this necessary high-frequency current. It has been found most convenient and satisfactory in the construction of furnaces under 100 kw. capacity to use as a source of high frequency current the oscillatory discharge of a bank of condensers.

By properly proportioning the capacity and inductances of the oscillatory current circuits the desired frequency is obtained.

While this type of furnace is perfectly adapted to operation on polyphase circuits with balanced load on the different phases, the particular furnace here described is constructed to operate on single phase only or on one phase of a polyphase supply. The electrical circuits employed for single phase operation appear in Fig. 1.

The line current may be supplied at 110, 220, or 440 volts and 60 cycles. A transformer  $Tr$  steps this e.m.f. up to about 8000 volts. A bank of condensers  $C$  is charged at this voltage and upon rupture of the gap  $G$  oscillations occur.

The current with free high-frequency oscillations passes through an "inductor" coil  $F$  which surrounds the crucible or mass  $M$  to be heated.

This inductor coil has from 50 to 80 turns only and yet its inductive effect is so powerful that currents of great magnitude are induced in the crucible walls, if this is conducting, or in the mass of conducting ma-

terial held in the crucible, if the crucible is non-conducting. The mass  $M$  heats with great rapidity, the inductor coil itself remaining practically cool. A small quantity only of heat-insulating material surrounding

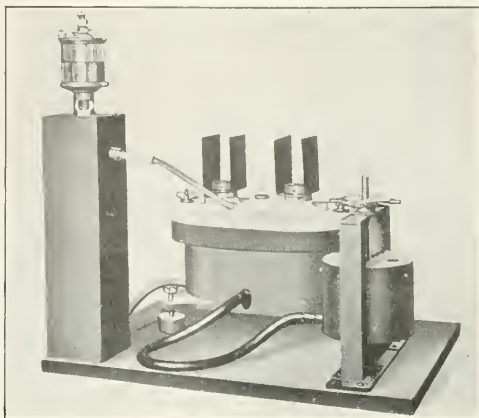


FIG. 2—DISCHARGE GAP

the crucible is required to retain the heat developed. As this heat is developed within the mass to be heated and is not absorbed from an outside supply of heat, as in the resistance wound furnace, it is possible to obtain very high temperatures. No material other than the crucible and its contents is subjected to a destructive temperature, and consequently this type of furnace never burns out and so becomes inoperative.

A series reactance  $X_c$  with tap-offs permits perfect regulation of the power consumed, and another reactance  $X_s$  connected in shunt to the line on the primary side of the transformer serves to adjust the power-factor of the line to be practically unity. If power is supplied from a source of lagging current,  $X_s$  can be so chosen as to improve the power factor.

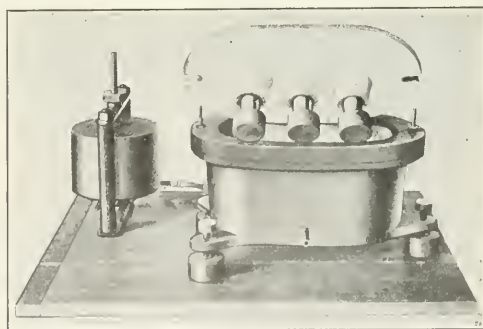


FIG. 3—INTERIOR VIEW OF DISCHARGE GAP

The power which the furnace will absorb from the source of supply is exactly proportional to the number of condenser units used in the bank of condensers which go to make up the capacity  $C$ . Calculation and experiments show that for the size of unit adopted, which is in over all dimensions 12 x 16 x 13 in. and in capacity 0.07 m.f., 1.5 kw. p.r unit can easily be obtained. Thus a



bank of 16 condenser units is required for a 20 kw. furnace outfit. Of the power supplied at the main switch terminals not less than 50 to 60 per cent makes its appearance as heat in the crucible and contents, being heated by induction.

The discharge gap is also of a radically new type. It has no moving parts and consists essentially of two graphite electrodes (three for two-phase or three-phase operation) opposed to a level surface of mercury. The mercury is contained in a cast-iron pot. The level of the mercury is made adjustable by means provided for lowering and raising an outside reservoir of mercury. The electrodes with graphite tips project through the tightly closed cover. As the discharge takes place in a tightly closed chamber, the noise from the discharge is slight and not at

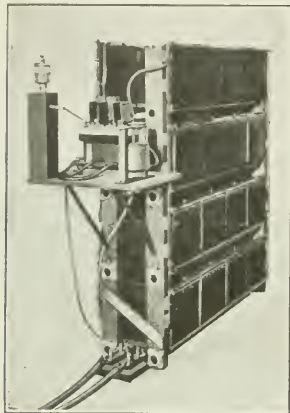


FIG. 4.—OSCILLATORY CURRENT SYSTEM ASSEMBLY

all objectionable. This gap is found to operate better and the surface of the mercury remains clean if alcohol is slowly dropped into the chamber at about 15 drops a minute.

In Fig. 2 is shown a reproduction of a photograph of a mercury discharge gap with alcohol dropper and mercury regulator. In Fig. 3 is shown a gap with its cover raised to expose to view the electrodes (only two of which are used in single phase operation).

In Fig. 4 is shown a photographic reproduction of a 20-kw. oscillatory current system. It consists of a bank of 16 condenser units and a discharge gap.

Fig. 5 is a photographic reproduction of an oscillatory current furnace of the vacuum type. The practical results obtainable with this new type of induction furnace are numerous and important:

(a) Temperatures exceeding 1600 deg. C. are readily obtained.

(b) Most all nonferrous metals are readily fused without contamination of any kind. The fusion can be made in air or in any desired atmosphere or in vacuum.

(c) Pure iron and pure nickel are readily fused free from contact with carbon.

(d) A nonconductor, as enamel or a high melting glass, is readily fused. Porcelain samples and clays can be studied at temperatures used in firing.

(e) A bath of molten tin, lead or any salt may be uniformly heated and the temperature controlled so that it may be used for heating steel for hardening.

(f) The furnace can be varied in size and form to adapt it to any special requirements. It may be of horizontal, of vertical cylindrical type, or of the muffle type.

(g) A uniform high temperature, up to 1600 deg. C. or more, with a 16-condenser unit outfit, may be main-

tained throughout the volume of a cylinder 6 in. in diameter and 12 in. long, for any kind of heat treatment, such as the heating of iron or steel to be forged. This temperature may be obtained in less than 40 minutes starting cold.

(h) The furnace is admirably adapted to the making of almost all kinds of alloys. The separate constituents can all be heated up from the cold and the alloy allowed to solidify without cracking the container, and if desired may again be heated to fusion without injuring the container. This furnace was invented and developed by Dr. E. F. Northrup for the Ajax Metal Company of Philadelphia. It is manufactured and sold by the Pyroelectric Instrument Co., Trenton, New Jersey. An illustrated 20-page circular describing this furnace has been recently prepared for distribution.

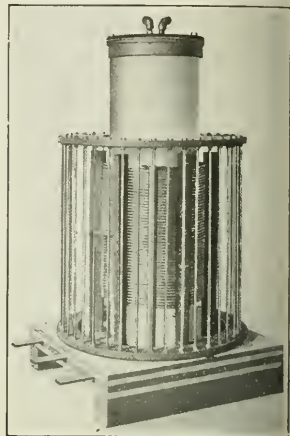


FIG. 5.—STANDARD VACUUM TYPE OF FURNACE

## Hydraulic Operation of Furnace Doors

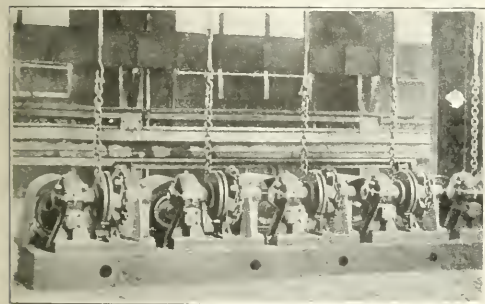
THE operation of heavy doors, such as are used on open-hearth and heating furnace work, is usually accomplished by the use of hydraulic systems, consisting of pumps, pressure tanks, high pressure pipes, three-way valve, etc. On account of the fact that doors must go up when wanted to go, and vice versa, and due also to the fact that water under pressure has been reliable in the past, the hydraulic system has almost universally been adopted. This is also proof of the fact that no fool-proof, absolutely dependable electric control has ever been worked out before for open-hearth work. A few electric attachments have been made, but they resulted in failure.

The Alan Wood Iron & Steel Co., Conshohocken, Pa., have had in use for thirteen or fourteen months, five hoists with an automatic release, invented by one of their men and manufactured by the Link-Belt Company. These hoists have been in continuous and regular operation without any repairs, attention, or maintenance expense whatever. The illustration shows each hoist provided with a pair of chain sheaves, mounted loose on a worm wheel shaft, between two flanges which are pinned to the shaft and supplied with fiber friction surfaces on the sides toward the sheaves. The worm wheel is driven by a worm mounted on the shaft of a reversible motor, the worm and wheel being enclosed in suitable housing.

To the left-hand sheave is attached a chain which leads up to the tackle for raising the furnace door, and to the right-hand sheave is fastened a chain from which

is suspended a heavy counterweight (down behind the mechanism shown). The wrap of the chains around the sheaves is in opposite directions. The contact surfaces between the sheaves have a beveled, or spiral shape, with the result that when both chains are under tension, the sheaves are squeezed tightly against the friction flanges at the sides, and thus compelled to rotate in the direction of motion of the worm wheel shaft.

To raise the furnace door, the motor is started in the direction which will pull down on the left-hand chain. As long as the counterweight continues its pull, the sheaves squeeze out against the flanges, and are thereby driven in the direction which will wind up the left-hand chain, and thus lift the door. The right-hand sheave has a fixed stop on its periphery, so located that it will come in contact with a stop on the bottom casting when the furnace door has reached its proper height. With the motion of the right-hand sheave arrested by this stop, the shaft cannot rotate the left-hand sheave further, because the squeeze between the sheaves and friction flanges is relieved. There is no opportunity, therefore, for over-winding, and if through carelessness



THE LEWIS HYDRAULIC HOIST

the current is not shut off promptly, the shaft with its flanges will simply continue to revolve in sliding frictional contact with the sheaves, but without power to grip and rotate them further.

For lowering the doors, the direction of the motor is reversed, and practically the same process repeated, except that in this case the power of the motor is used to lift the counterweight, while the pull from the weight of the door serves to keep the sheaves squeezed apart against the friction flanges, until a stop on the left-hand sheave engages with a stop on the bottom casting, and prevents over-winding of the counterweight chain in the same manner as described for the other sheave. In other words, the door always goes up to the proper position, and always comes down to the proper position, no matter what its weight may be. Even if the door were considerably heavier than the counterweight, there would be no danger of its descending and pulling the counterweight up when the motor is stopped, for the instant the counterweight sheave is started toward reversal, the pull of its chain would squeeze the sheaves apart against the friction flanges, and the two sheaves would thus be put completely under control of the worm wheel shaft again, and the worm wheel is, of course, locked in position by the worm. The stop feature does away with the automatic electric switch devices

which have proved so troublesome for this type of hoist, as well as for skip hoists; and it secures an exact stop for all such hoists, without involving failure from human carelessness or complicated electrical equipment. The motor is started, stopped or reversed by simple push-button mechanism.

In the case of skip hoists, the sheaves of course, would be replaced by drums. Doubtless various other applications of the device will suggest themselves; and the fact that it is entirely fool-proof will be appreciated as a great advantage.

### Developments in Grading Solids

STARTING with information drawn from hand sieving, engineers developed an enlargement of this apparatus and called it a shaking screen. All sorts of mechanical motions were applied—eccentrics, toggles and rotators—all being highly successful except for the clogging of the finer meshes. Screen cylinders were developed and somewhat improved by hexagon and octagon forms, but still the milled material tended to accumulate and clog the wires.

Finally the inclined screen with tightly strung wires to which vibrating knockers were applied was evolved. Several advantages were to be had in this form of appliance. Several sizes can be graded at one time; the operation is continuous and regular; the coarser meshed screens, being on top, protect the finer and more delicate ones beneath. The size of the product varies with the cosine of the angles of the incline—200 mesh material is obtained on a 100 mesh weave when the slope is 60 degrees—so that heavier screens can be used for any given work. This gives greater wearing properties besides permitting greater vibrations. Moreover, clogging never takes place.

Of this type of appliance, the new Super Newaygo, manufactured by the Sturtevant Mill Co., Harrison Square, Boston, Mass., is very substantially built and designed for unit construction so any capacity desired can be assembled. All the parts are instantly accessible and can be quickly repaired by replacements when necessary. The coarse screen acts as a scalper and is located in the cover, which is so counterweighted that it can be raised with one hand, leaving the finer screen fabrics accessible. Very efficient knockers apply sufficient vibration to keep the mesh wires clear.

### Licensing of Engineers

At the regular meeting of Engineering Council June 20, a special report by the Public Affairs Committee on the Licensing of Engineers, was debated at length. It was decided to create a small Special Committee, with very carefully selected membership, to study this important question thoroughly with a country-wide view. It is intended that through the work of this committee, Engineering Council shall in due time be prepared to advise engineering organizations in any of the states upon this much discussed matter. Engineers who have knowledge of proposed legislation are requested to communicate with the Secretary of Engineering Council. Information or rumor has already been received of possible action by the Legislatures of Iowa, Ohio, Indiana and Michigan. As is well known, a few states have passed laws.



## Book Reviews

**THE HISTORY OF CHEMISTRY**, by Prof. T. S. Moore. 240 pages. Price, \$2.50. New York: McGraw-Hill Book Co., Inc.

According to Dr. George Sarton, erstwhile of the University of Ghent, the history of science is the history of man's conquest over nature. In this respect only has man been constantly progressive. In religion, in morals, and in arts, the question of his steady advancement is open to discussion, whereas in science his advancement has been slow but continuous. Therefore, if we would know man as a progressive creature, we must consider him from the angle of vision in which this quality comes into view. If we would make a just estimate of the present from the past and would compute the future in the light of human advancement, we shall need the history of science to enlighten us. The history of science is therefore of value from an ethical standpoint.

And now Professor Moore has given us a textbook on the subject of chemistry. From beginning to end the pinch of space is felt, because the subject is one for a whole library rather than for a single book, and with such wealth of material it was necessary to compress and delete and squeeze until only the high lights are touched upon. And these high lights, like John Mayow, come out of the shadow of the past and flit by so swiftly that the little glimpses we get seem all too short and inadequate. But we are dealing with a textbook on the history of chemistry and it is the business of a textbook to whet the appetite.

Dr. Moore addressed himself to a history of the science rather than a record of the men who made it, and this gives us an excellent short memorandum of its development. Only six pages cover the history of the Greek contributions and but eight pages are devoted to alchemy; then we begin with the Renaissance, with Paracelsus the first chemist.

But even here there are only seven pages to lead us along through the iatro-chemists, from Phillippus Aureolus Paracelsus Theophrastus Boombastus Eremit von Hohenheim, born in 1493, to and including Johann Rudolf Glauber (1604-1668) who sold secret medicinal preparations, including the salt that bears his name. These notes include a memorandum on Agricola who, although a physician, was rather a metallurgist than an iatro-chemist, as is duly pointed out.

At this point we reach a rebirth in chemical philosophy, beginning with Robert Boyle (1627-1691). From the time of the Greeks until Boyle's day, it would seem that whatever there was to chemistry had been kept outside of the pale of distinguished scholarship. The alchemists worked in secret and their ideals were not such as to attract men of character. Albertus Magnus and Roger Bacon seem to have been men of vision, although the usual alchemistic purpose was to get rich quick by a clever trick. To devote a life to finding how this may be done has never appealed to the best quality of men.

Robert Boyle was a gentleman by birth, training, education and character, and his advent gave the signal for high thinking, open-mindedness and frankness. By the very merit of his work he put the quack doctors where they belonged without the trouble of quarreling with them. He did it very simply—by outclassing them. When we look up we look for the top and when men of his day looked toward the top in chemistry they found a gentleman and a scholar instead of an itinerant quack doctor with secrets to sell. Then chemistry began to grow and, in spite of Stahl's unfortunate injection of phlogiston into the subject, Boyle had set the pace.

Dr. Moore gives a photograph of a page of Stahl's "Fundamenta Chemicæ," which was begun in Latin but finished in German. The page in question is from the middle of the book and we shall give only part of a sentence to show his style. It is no wonder that a man who wrote like this should confuse chemistry! "Denn es gehen in dieser Dissolution des nitri, idem sich die Mixtur entzündet, variae portiones in forma flammæ weg, und machen einen

Rauch welche eine kuenstlich, applicato scil. super crucibulum recibulum recipiente fangen; nemlich sie thun diese Mixtur in ein gluehend Geschirr . . . und der Dunst . . . wird gefangen, da er sich in einen Liquorem condensirt, qui vero plane alienus est a Spiritu nitri iridole. . . ."

The book proceeds rapidly over the thorny road of phlogiston, giving, in carefully arranged sequence, what was thought by men who have made leading contributions to chemistry on the subject in hand. The problem of the author required that this be done and limitations of space doubtless required that only the merest reference be made to the personality of most of these men. This is the criticism we have to make and we do so without blaming the author or the publishers. A textbook must be compact. It is richly illustrated, chiefly by means of portraits of great men, but we would prefer their biographies to their likenesses.

There are two methods of teaching history. One is the method selected by the author to give a history of the subject and to mention the leaders as incidents in its development. This is the short and compact method. The other is to provide a more general record of progress and then to confirm the steps by giving biographical sketches of the leaders, including such personal details concerning them as will confirm them in memory. This takes more time and is less orderly, but it has its advantages. It humanizes the subject and that makes it more likely to be remembered. There is in this book a delightful little sketch of John Dalton written by himself which shows him as a school teacher at twelve years of age, and there is also a living and sincerely appreciative picture of Liebig, which is very charitable withal. Of Berzelius we should like to know more, although he is recorded as the organizer of the science. It is, on the whole, a scholarly work and, so far as we have been able to observe, it is unusually free from error.

## Personal

MR. PHILIP R. BRADLEY, of Treadwell, has been appointed Food Administrator for Alaska.

MR. HENRY CASE, until recently director of technical research with the David-Bournonville Co., Jersey City, N. J., has assumed the duties of production manager of the S. K. F. Ball Bearing Co., Hartford, Conn.

MR. L. G. EAKINS, for years general manager of the Colorado branch of the American Smelting and Refining Company, has resigned his post in Denver and will move to New York City as consulting metallurgist for the smelting corporation. He will be succeeded in Denver by C. A. H. DeSaules, who has held an important place with the company in New York City. In New York Mr. Eakins will be located at 120 Broadway.

MR. JAMES H. HUGHES has been appointed manager of the steel and tube department of the Timken Roller Bearing Company at Canton, Ohio, effective July 1. He was formerly with the Carnegie Steel Company, having spent fourteen years in that organization.

MR. J. W. HUTCHINSON, former manager of Goldfield Consolidated Mines Co., has resigned to join the Army. He is succeeded by E. A. Julian, former chief engineer of the Wingfield interests.

MR. G. J. KAPTEYN, a Dutch engineer widely known and traveled in metallurgical and mining districts in both Americas, has passed through the United States en route to the East Indies on Dutch government business.

MR. A. D. LEDOUX has been appointed chairman of the Chemical Alliance Committee on the Production, Distribution and Control of Sulphur Materials. His associates are W. D. Huntington and C. G. Wilson. Headquarters are at Room 135, Interior Building, Washington, D. C., or 15 William St., New York City.

MR. H. J. MORGAN, of the General Chemical Company, has been transferred from the Delaware Works at Marcus



Hook, Pa., to the main laboratories of the company at Laurel Hill, Long Island, where he will be chemist in charge.

PROF. C. W. PARMELEE, of the department of ceramic engineering, University of Illinois, Urbana, Ill., is making a survey of the ball-clay deposits of West Tennessee.

MR. JOEL H. WATKINS, formerly economic geologist for the Southern Railway System, has opened an office at Room 1364, 200 Fifth Avenue, New York. He intends to devote special attention to the mineral resources of the Appalachian South.

DR. THEODORE W. RICHARDS, Erving professor of chemistry and director of the Wolcott Gibbs Memorial Laboratory at Harvard University, has been made a foreign member of the Accademia dei Lincei, Rome. He has been elected an honorary member of the Royal Irish Academy.

MR. H. E. SHIVER, assistant chemist, South Carolina Experiment Station, Clemson College, S. C., and formerly a member of the United States Army Flying Corps at Princeton University, has accepted a position as chemical engineer with the Air Nitrates Corporation at their electrochemical plant at Muscle Shoals, Ala. He will be in a supervisory position in unit 5 of the plant.

MR. ARTHUR H. YOUNG, director of the American Museum of Safety since January 1, 1917, has resigned to take charge of the Employee Relations Department of the International Harvester Company. He will take up his new duties immediately but will continue to be closely concerned with museum affairs, as he has been elected to the vice presidency, succeeding the late Dr. Frederic R. Hutton.

Obituary

PROFESSOR STEPHEN FARNUM PECKHAM, chemist and authority on bitumens, died at his residence at Brooklyn on July 11, at the age of seventy-nine. Professor Peckham was born at Fruit Hill, Providence, R. I., and was educated at the Friends School and at Brown University. From 1869 to 1873 he taught chemistry at Washington College. Later he held the chair of chemistry at Maine State College and at the University of Minnesota. He was also chemist to the Minnesota Geological Survey and the State Board of Health.

From 1898 to 1911, he conducted a laboratory for the Commissioners of Accounts and later for the Finance Department of New York. He contributed scientific articles to the Encyclopedia Britannica, the American Encyclopedia and Chemical News, and wrote a treatise on asphalt. Nine years ago, he suffered a stroke of paralysis, which ultimately caused his death. His wife, two daughters and a son survive him.

Current Market Reports

Non-Ferrous Metal Market

Thursday, July 25.—With strong demand and higher labor costs, prices still tend to increase except where fixed by regulations.

Aluminium.—The government price on ingots is 33c. a pound f.o.b. plant in 50-ton lots, 33.1c. down to 15-ton lots, and 23.2c. in lots down to 1 ton, and 40 to 45c. for smaller lots; sheet aluminium, 18 ga. and heavier, 42c.; and powdered aluminium, \$0.65 to \$3.00 per lb. according to mesh.

Antimony.—The demand is developing and spot duty paid has advanced to 13 1/4 to 13 1/2 c.

Chrome.—Producers have established a schedule on the basis of \$1.30 per unit ore; some 40% ore has been sold at a premium at \$1.50 per unit.

Copper.—Government price fixed at 26c. until August 15. Copper products are quoted at:

|                            |        |   |            |
|----------------------------|--------|---|------------|
| Copper sheets, hot rolled  | \$0.36 | — | \$0.37 1/2 |
| Copper sheets, cold rolled | .37    | — | .38 1/2    |
| Copper bottoms             | .44    | — | .45 1/2    |
| Copper rods                | .36    | — | .37        |

|                        |         |           |
|------------------------|---------|-----------|
| Copper wire            | .29 1/2 |           |
| High brass wire        | .28 1/2 | — .29 1/2 |
| High brass sheets      | .28 1/2 | — .29 1/2 |
| High brass rods        | .28 1/2 | — .29 1/2 |
| Low brass wire         | .32 1/2 | — .34 1/2 |
| Low brass sheets       | .32 1/2 | — .34 1/2 |
| Low brass rods         | .34 1/2 | — .35 1/2 |
| Brazed brass tubing    | .37     | — .39     |
| Brazed bronze tubing   | .42 1/2 | — .44 1/2 |
| Seamless copper tubing | .41     | — .43     |
| Seamless bronze tubing | .45     | — .46     |
| Seamless brass tubing  | .37 1/2 | — .39 1/2 |
| Bronze (gold) powder   | 1.00    | — 1.75    |

Lead.—Metal scarce for spot delivery. Price in New York 8.05c. per lb., in East St. Louis 7.75c. in 60,000-lb. lots; full lead sheets, 10c., cut sheets 10 1/4 c.

Manganese.—Such lots of manganese ore as reach New York are quickly taken at \$1.35 basis.

Molybdenum.—Quoted at \$1.25 per pound MoS<sub>2</sub> for 90 per cent material. There is considerable inquiry from abroad, but it is not known whether exportation will be permitted.

Spelter.—Bids are at 8.6c., while 8.75c. is asked. East St. Louis settling price is 8.40c. in 60,000-lb. car lots. Sheet zinc is 15c. and zinc dust 18 to 20c. per pound.

Tin.—Imports for the first three weeks of this month have been 5000 tons. Banca tin spot delivery for Government work has brought \$1.00 per pound, futures at 90 to 95c. Chinese tin for August shipment is quoted around 91c. Babbitt metal varies between \$1.10 and 70c. per pound. Solder 50-50, 73c.

Tungsten.—The highest grade material containing no tin, no copper and low manganese and over 70 per cent WO<sub>3</sub> is very scarce. Ore with slight impurities is bringing \$23.50 per unit, lowest grades down to \$18 per unit.

OTHER METALS

|           |        |                 |
|-----------|--------|-----------------|
| Bismuth   | lb.    | \$3.50          |
| Cadmium   | lb.    | 1.50            |
| Cobalt    | lb.    | 2.50 — \$3.50   |
| Magnesium | lb.    | 1.75 — 2.00     |
| Mercury   | 75 lb. | 125.00 — 130.00 |
| Nickel    | lb.    | 40.00 — 45.00   |
| Iridium   | oz.    | 175.00          |
| Palladium | oz.    | 135.00          |
| Platinum  | oz.    | 105.00          |
| Silver    | oz.    | .99 1/2         |

The Iron and Steel Market

While much of the discussion relating to supplies and requirements in steel relates to the demand that is not accorded any form of precedence by the controlling authorities and to the supplies that may be left for such purposes after the preferences, etc., are met, the fact is that by far the most important matter in steel distribution is the distribution under the priorities and preferences. Steel producers quite familiar with the situation continue to estimate that the demand accorded no form of precedence does not amount to 10 per cent of the total demand, and thus it is relatively unimportant when the 90 per cent or more is very far from being fully taken care of.

The trade has become familiar with the new nomenclature and regulations prescribed by the War Industries Board's statement dated July 3 and subsequently circulated to the trade. The sequence in which wants are to be taken care of is as follows: Priorities, AA, A and B, respectively, with certain subnumbers; Preferences, or Class C; Class D, or all other.

The priorities are precise orders, requiring a producer to furnish a consumer a specified quantity of material. It is not necessary that all priority orders be actually filled before any material is shipped under preferences, but merely that they shall be "provided for," i.e., the producer must be assured that the manufacturing facilities are set aside to the extent necessary to make the shipment in good time.

The preference list, while given as an appendix in the statement of July 3, is substantially the list originally promulgated under date of June 6. It prescribes the sequence of importance, and runs from direct war purposes through to peace or commercial purposes of the more important character, the purposes being in brief: Ships, aircraft, munitions, fuel, food, clothing, railroad, public utilities. All these classes, it is now clearly understood, are to be interpreted broadly. Food, for instance, covers everything in the production and preparation of food, even to the

production of cook-stoves and cooking utensils for the household, though there is an order of sequence here also, and the public is expected to get along with as few new cook-stoves as possible. The mills are expected to use their judgment in these matters, referring doubtful cases to Washington.

The Class D material is subject to production and shipment only by written permit of the Director of Steel Supply, except that shipments up to five tons are covered by a blanket permit, subject to the restriction that the producer must report all such shipments monthly and certify a belief that they were "in the public interest."

The jobbers are placed under the same restrictions as the producers in the matter of making shipments. They are required to report shipments and are to be given replacement of material against approved shipments. They are, however, required to endeavor to get along with as light stocks as possible and are expected to influence retail dealers to do the same.

#### NOT ENOUGH STEEL

With the amount of priority business on books and the government's demand for material under the preference list, there is far from enough steel to reach fully over the commercial purposes that are covered by the preference list. There is a divergence of opinion whether the more direct war needs are really of sufficient volume to require that the tail end of the preference list be ignored to a great extent. The War Industries Board holds that there is not nearly enough steel production in prospect to meet all requirements, while many in the steel industry maintain that the war activities will not be able, during the next few months, to consume steel as rapidly as they are calling for it.

The discussion centers largely around a recent statement of the War Industries Board, that the requirements for the second half of the year total about 21,000,000 net tons, while the steel industry has never produced more than 16,500,000 net tons in a half year. But little explanation is given of these bare totals. There is no attempt made to indicate how the 21,000,000-ton total is made up, and as to the 16,500,000 tons production, assumed to be net tons, the fact is that in 1916 the production of finished rolled steel was about 34,200,000 net tons. The production in June was at the rate of about 36,000,000 net tons a year, assuming, as seems fair, that finished rolled steel was 75 per cent of the ingot tonnage, indicated by partial reports to have been at the rate of 43,500,000 gross tons a year.

While details have not been made public, it is evident that the 21,000,000-ton estimate must have been made up of material in two categories, first the stated requirements of the various Government activities—shipbuilding, shell manufacture, aircraft production, requirements of our allies, etc.; second, estimates of what the recognized commercial industries will require. From some of these industries estimates may have been received, but it is rather clear that "public utilities" were unable to make precise estimates, if indeed they individually made any at all.

It may be that the Shipping Board has overstated the amount of steel it will be able to use to January 1, 1919, and it may likewise be that it will be so successful in its work as to be able to consume more steel than it now estimates. What is clear is that with everyone trying to produce and consume a maximum it cannot be foretold precisely what will be done. The War Industries Board, therefore, sets a high mark for the steel industry to aim at, and is very conservative in allowing steel to pass to the less important commercial industries.

While according to the estimates are forecasts that there is not to be enough steel, the actual situation is not such by any means. There are many jobbers and manufacturing consumers who insist that they need more steel, but in most cases it is a case of looking into the future. There is, after all, very little if any work of real importance that is being retarded seriously if at all by lack of steel. The shipyards are in many cases accumulating steel and few if any are hampered by lack of steel. The forge shops, making shell blanks, are in the main well supplied and it is rumored that some have uncomfortably large stocks. At the shell factories there seems to be a fairly good supply

of material. The railroads doubtless could use more cars, but their performance is improving each month through better organization.

#### PIG IRON

If there were a normal supply of scrap, in proportion to pig iron, there would probably be no shortage of pig iron, for the requirements of the iron foundry trade in general are quite below normal. The total supply of scrap is insufficient, and the average character of scrap available is much below normal. Accordingly more pig iron is required, and with the increased proportion of pig iron for open-hearth furnaces using the pig and scrap process the ingot output is below the ordinary ratings of capacity. There is, however, no acute shortage of pig iron.

#### Chemical Market

**COAL TAR PRODUCTS:**—The last two weeks' period has been marked by the usual summer quietness although in those items which have shown some activity there have been slight increases in prices quoted. The saccharines have shown a continuing advance with the growing demand and the soluble still holds the preference.

**Phenol:**—Even inquiry has been very quiet for this material and large factors in its production are offering at 44c for material in large quantities on contract. Certain other directions continue to hold at 45c although on resale there is material available at less than either figure. Actual holdings of the English material are at local warehouses but holders state that it is not expected that further importations will be made. These are being offered at 45c, ex store.

**Aniline Salts:**—A very limited supply of this material is available even on the resale market and large manufacturers state that they are all sold up and are quoting 42c per pound. Demand is very good but holders are very hard to locate.

**Saccharine:**—The soluble material continues in favor and in very strong demand. Manufacturers are behind in filling contracts so far back as April and it has become almost impossible to locate holdings in second hands. The last sales reported were at \$32 on the soluble and \$31 on the insoluble.

**Coumarin:**—This product also is at present very short in supply as compared with demand and large interests who are succeeding at all in receiving shipments are doing them out sparingly among their regular customers. Such interests quote general prices of from \$28 to \$30, but as to the resale market in the few instances where actual holdings are known quotations are on the basis of \$32.50.

**Benzoate of Soda:**—The demand for this product has fallen off in the last week until there is practically no call. Purchases can be made at \$2.90 although the general holding is at \$3.00. The acid has assumed a level of from \$3.10 to \$3.25.

**Dimethylaniline:**—Demand is fair for this time but actual holdings are hard to locate. Small quantities are being offered from time to time and the present asking price for such lots is from 75 to 80c.

**Paranitraniline:**—The demand continues very good and new sources of supply are available. Such offerings are made at from \$1.75 to \$1.80.

**Hexamethylenetetramine:**—The demand for this material has fallen off somewhat from the active demand of a week or two ago and prices asked by large producers are now at \$1.05 and \$1.10 depending upon quantity. Large quantities cannot be delivered because of the scarcity of raw materials. Production is also affected by the present labor and transportation conditions and the fact that the government is taking over a large portion of the production.

**Meta Amidophenol:**—Supplies are not very large as the manufacture is for special color purposes and only small advance stocks of material are kept on hand. It is thought that the price of \$6.50 which is quoted in certain directions could be bettered on firm orders.

**HEAVY CHEMICALS:**—Although the market in general has been very quiet caustic soda has shown some little activity. In the case of saccharine a tendency to the returning of the old relations between the soluble and insoluble is evident.

**Bichromate of Soda:**—The majority of stocks are held by very strong houses and there is very little competition. The last sales noted were at 26½¢ and it was thought that 26¼¢ could be done although there are some holders who will not shade 30¢ at the same time admitting that there seem no immediate prospects of receiving this price.

**Caustic Soda:**—Material from store is being quoted at \$3.80 and \$3.90 in several directions but from one source, an export house, it is reported that \$4.25 could not be shaded on a delivered price. Some 2700 tons were recently ordered through the Japanese government for one of the companies operating in Japan under subsidy. Part of this order was shipped in June and the balance was booked for July. The Japanese government arranged for the necessary permits.

**Soda Ash:**—Offers on double bags at Chicago have shown a slight increase as \$3 is last reported to have been paid as against \$2.65 recently. There is very little activity in the local market as bags are held at \$2 store in some quarters although some are quoting \$2.05 and \$2.10. The price on barrels New York continues at about \$2.90 with dense ash at \$3.85 or \$4 f.a.s.

**Bichromate of Potash:**—There has been a slight movement with offers generally made at 43 and 44c, without attracting much buying attention.

**Lead Peroxide:**—It is reported that new manufacturers are entering the field and will produce this material in powdered form on which they are quoting a price of 35¢ per pound and accepting orders for any quantities.

**Calcium Carbide:**—This item has been showing a gradual increase and is expected to reach ultimately the 20c level. The last general quotations for the sizes in greatest demand were at 19c at which the market appears to be very well established.

## General Chemicals

WHOLESALE PRICES IN NEW YORK MARKET, JULY 8, 1918

|                                               |      |               |       |
|-----------------------------------------------|------|---------------|-------|
| Acetic anhydride                              | lb.  | 1.60          | 1.85  |
| Acetone, drums                                | lb.  | Nominal       |       |
| Acid, acetic, 28 per cent                     | lb.  | Nominal       |       |
| Acetic, 50 per cent                           | lb.  | Nominal       |       |
| Acetic, glacial, 99½ per cent, carboys        | lb.  | Nominal       |       |
| Boric, crystals                               | lb.  | 1.14          | .15   |
| Hydrochloric, C. P.                           | lb.  | Nominal       | .88   |
| Hydrochloric, 20 deg.                         | lb.  | .02           | .02½  |
| Hydrochloric, conc., 22 deg.                  | lb.  | .02½          | .03   |
| Hydrofluoric, 30 per cent in barrels          | lb.  | .06           | .06½  |
| Lactic, 44 per cent                           | lb.  | .15           | .16   |
| Lactic, 22 per cent                           | lb.  | .06           | .07   |
| Mol'dic, C. P.                                | lb.  | 6.90          | 7.40  |
| Nitric, 36 deg.                               | lb.  | Nominal       |       |
| Nitric, 42 deg.                               | lb.  | .08½          | .10   |
| Oxalic, crystals                              | lb.  | .42           | .44   |
| Phosphoric, 47-50 per cent paste              | lb.  | .08           | .10   |
| Phosphoric, ref. 50 per cent                  | lb.  | .35           | .40   |
| Picric                                        | lb.  | Nominal       |       |
| Pyrogallol, resublimed                        | lb.  | 3.25          | 3.50  |
| Sulphuric, 60 deg                             | ton  | Nominal       |       |
| Sulphuric, 66 deg                             | ton  | Nominal       |       |
| Sulphuric, oleum (Fuming), tank cars          | ton  | Nominal       |       |
| Taenic, U. S. P., bulk                        | lb.  | 1.48          | 1.53  |
| Tartaric, crystals                            | lb.  | .86           | .95   |
| Tungstic, per lb. of W                        | lb.  | 1.70          | 1.75  |
| Alcohol, sugar cane, 188 proof                | gal. | 4.91          |       |
| Alcohol, wood, 95 per cent                    | gal. | .91½          | .92   |
| Alum, denatured, 180 proof                    | gal. | .68           | .69   |
| Alum, ammonium lump                           | lb.  | .04½          | .05½  |
| Alum, chrome ammonium                         | lb.  | .18           | .19   |
| Alum, chrome potassium                        | lb.  | .20           | .21   |
| Alum, chrome sodium                           | lb.  | .12½          | .13   |
| Alum, potash lump                             | lb.  | .09           | .09½  |
| Aluminium sulphate, technical                 | lb.  | .02½          | .03   |
| Aluminium sulphate, iron free                 | lb.  | .03½          | .04   |
| Ammonia aqum, 26 deg., carboys                | ton  | Nominal       |       |
| Ammonia, anhydrous                            | lb.  | Nominal       |       |
| Ammonium carbonate                            | lb.  | .15           | .16   |
| Ammonium nitrate                              | lb.  | (Fixed Price) | .07   |
| Ammonium sulphate domestic                    | lb.  | .07½          | .08   |
| Amyl acetate                                  | gal. | 5.25          | 5.60  |
| Arsenic, white                                | lb.  | .09½          | .10   |
| Arsenic, red                                  | lb.  | .65           | .70   |
| Barium carbonate, 99 per cent                 | ton  | 80.00         | 90.00 |
| Barium carbonate, 97-98 per cent              | ton  | 65.00         | 67.00 |
| Barium chloride                               | ton  | 65.00         | 70.00 |
| Barium sulphate (Blanc Fixe, Dry)             | lb.  | .04½          | .05   |
| Barium nitrate                                | lb.  | .10           | .11   |
| Barium peroxide, basis 70 per cent            | lb.  | .30           | .32   |
| Bleaching powder, 35 per cent chlorine        | lb.  | .02           | .03   |
| Boric, crystals, sacks                        | lb.  | .07½          | .10½  |
| Brimstone, crude                              | ton  | Nominal       |       |
| Bromine, technical                            | lb.  | .75           |       |
| Calcium acetate, crude                        | lb.  | Nominal       |       |
| Calcium carbide                               | lb.  | .15           | .16   |
| Calcium chloride, 70-75 per cent, fused, lump | ton  | 22.00         | 24.00 |
| Calcium phosphate                             | lb.  | 1.60          | 1.70  |
| Calcium phosphide                             | lb.  | .22           | .23   |
| Calcium sulphate 98-99 per cent               | ton  | .09           | .09½  |
| Carbon bisulphide                             | lb.  | .08½          | .09   |
| Carbon tetrachloride, drums                   | lb.  | .15½          | .18   |
| Carbonyl chloride (phosgene)                  | lb.  | 1.10          | 1.50  |

|                                                 |         |               |        |
|-------------------------------------------------|---------|---------------|--------|
| Caustic potash, 88-92 per cent                  | lb.     | .77½          | .80    |
| Caustic soda, 76 per cent                       | 100 lb. | 3.90          | 4.00   |
| Chlorine, liquid                                | lb.     | (Fixed Price) | .07½   |
| Cubalt oxide                                    | lb.     | 1.60          | 1.65   |
| Copperas                                        | lb.     | .02           | .02½   |
| Copper carbonate                                | lb.     | .29           | .32    |
| Copper cyanide                                  | lb.     | .75           | .78    |
| Copper sulphate, 99 per cent, large crystals    | lb.     | .094          | .09½   |
| Cresol of tartaric crystals                     | lb.     | .62           | .65    |
| Epoam salt, bags, U. S. P.                      | lb.     | 3.62½         | 3.90   |
| Formaldehyde, 40 per cent                       | lb.     | .16½          | .17½   |
| Glauber's salt                                  | lb.     | .02           |        |
| Glycerine, bulk, C. P.                          | lb.     | .62           | .65    |
| Iodine, resublimed                              | lb.     | 4.25          | 4.30   |
| Iron oxide                                      | lb.     | .13           | .15    |
| Lead acetate, white crystals                    | lb.     | .13           | .18    |
| Lead arsenate (Pasto)                           | lb.     | .15           | .18    |
| Lead nitrate                                    | lb.     | Nominal       |        |
| Litharge, American                              | lb.     | .11½          | .13    |
| Lithium carbonate                               | lb.     | 1.50          | 2.00   |
| Magnesium carbonate, technical                  | lb.     | .14           | .15    |
| Nickel salt, single                             | lb.     | .14           | .15    |
| Nickel salt, double                             | lb.     | .12           | .14    |
| Phosgene, (see Carbonyl chloride)               | lb.     |               |        |
| Phosphorus, red                                 | lb.     | 1.15          | 1.20   |
| Phosphorus, yellow                              | lb.     | 1.35          | 1.40   |
| Potassium bichromate                            | lb.     | .46           | .47    |
| Potassium bromide granular                      | lb.     | 1.35          | 1.49   |
| Potassium carbonate calcined, 85-90 per cent    | lb.     | .38           | .40    |
| Potassium chlorate, crystals                    | lb.     | .38           | .40    |
| Potassium cyanide, 98-99 per cent               | lb.     | .60           | .70    |
| Potassium iodide                                | lb.     | 3.75          | 3.80   |
| Potassium muriate 80-85 p. c. basis of 80 p. c. | ton     | 300.00        | 350.00 |
| Potassium nitrate                               | lb.     | .27           | .31    |
| Potassium permanganate U. S. P.                 | lb.     | 1.35          | 1.75   |
| Potassium prussiate                             | lb.     | 2.80          | 2.90   |
| Potassium prussiate, yellow                     | lb.     | 1.10          | 1.20   |
| Potassium sulphate, 90-95 p. c. basis 90 p. c.  | ton     | Nominal       |        |
| Rochelle salts                                  | lb.     | .64           | .46    |
| Salammoniac, gray gran                          | lb.     | .22           | .23    |
| Salammoniac, white gran                         | lb.     | .17½          | .21    |
| Sal soda                                        | 100 lb. | 1.35          | 1.40   |
| Salt cake                                       | ton     | 35.00         | 40.00  |
| Silver cyanide, based on market price of silver | oz.     | 62½           | 64½    |
| Silver nitrate                                  | oz.     | 2.00          | 2.12   |
| Soda ash, 58 per cent, light, flat (bags)       | 100 lb. | 3.00          | 3.22   |
| Soda ash, 58 per cent, dense, flat              | 100 lb. | 3.00          | 3.22   |
| Sodium acetate                                  | lb.     | Nominal       |        |
| Sodium bicarbonate, domestic                    | lb.     | .02½          | .03    |
| Sodium bicarbonate, English                     | lb.     | .26           | .27    |
| Sodium bichromate                               | lb.     | .06           | .07    |
| Sodium bisulphite, powd.                        | lb.     | .25           | .25½   |
| Sodium chlorate                                 | lb.     | .13           | .14    |
| Sodium cyanide                                  | lb.     | .17           | .18    |
| Sodium fluoride, commercial                     | lb.     | 2.40          | 2.50   |
| Sodium hyposulphite                             | lb.     | 2.50          |        |
| Sodium molybdate, per lb. of Mo                 | lb.     | Nominal       |        |
| Sodium nitrate, 95 per cent                     | 100 lb. | .28           | .30    |
| Sodium nitrite                                  | lb.     | .35           | .45    |
| Sodium peroxide                                 | lb.     | .04           | .05    |
| Sodium phosphate                                | lb.     | .53           | .55    |
| Sodium prussiate, yellow                        | lb.     | Nominal       |        |
| Sodium silicate, liquid (60 deg.)               | lb.     | Nominal       |        |
| Sodium sulphide, 30 per cent, crystals          | 100 lb. | Nominal       |        |
| Sodium sulphide, 60 per cent, fused             | 100 lb. | Nominal       |        |
| Sodium sulphate, 90-95 per cent                 | ton     | Nominal       |        |
| Strontium nitrate                               | lb.     | .25           | .35    |
| Sulphur, flowers, sublimed                      | lb.     | .06           | .06½   |
| Sulphur chloride, drums                         | lb.     | .23           | .26    |
| Sulphur dioxide, liquid, in cylinders           | 100 lb. | 4.05          | 4.60   |
| Sulphur, flowers, sublimed                      | 100 lb. | 3.70          | 3.85   |
| Sulphur, roll                                   | ton     | Nominal       |        |
| Sulphur, crude                                  | ton     | Nominal       |        |
| Tin bichloride, 50 deg                          | lb.     | 1.00          | .29    |
| Tin oxide                                       | lb.     | .18           | .20    |
| Zinc carbonate                                  | lb.     | .15           | .15½   |
| Zinc chloride                                   | lb.     | Nominal       |        |
| Zinc cyanide                                    | lb.     | .14           | .16    |
| Zinc dust, 350 mesh                             | lb.     | .13           | .14    |
| Zinc oxide, American process XX                 | lb.     | .05           | .06    |
| Zinc sulphate                                   | lb.     | .05           | .06    |

## Coal Tar Products (Crude)

|                                        |      |               |       |
|----------------------------------------|------|---------------|-------|
| Benzol, pure, water white              | gal. | .23           | .26   |
| Benzol, 90 per cent                    | gal. | (Fixed Price) | 1.50  |
| Toluol, for non-military use, in drums | gal. | (Fixed Price) | 1.55  |
| Xylol, pure, water white               | gal. | .45           | .55   |
| Solvent naphtha, water white           | gal. | .12           | .15   |
| Solvent naphtha, crude, heavy          | gal. | .40           | .55   |
| Cresote oil, 25 per cent               | gal. | .30           | .32   |
| Dip oil, 20 per cent                   | gal. | .80           | 1.00  |
| Pitch, various grades                  | ton  | 1.05          | 20.00 |
| Carbolic acid, crude, 95-97 per cent   | lb.  | .60           | .65   |
| Carbolic acid, crude, 50 per cent      | lb.  | .35           | .38   |
| Carbolic acid, crude, 25 per cent      | lb.  | .18           | .20   |
| Cresol, U. S. P.                       | lb.  | .35           |       |

## Intermediates, Etc.

|                              |     |         |       |
|------------------------------|-----|---------|-------|
| Alpha naphthol, crude        | lb. | 1.00    | 1.10  |
| Alpha naphthol, distilled    | lb. | 1.60    | 1.70  |
| Alpha naphthylamine          | lb. | .60     | .65   |
| Aniline oil, drums extra     | lb. | .27     | .28   |
| Aniline salts                | lb. | .37     | .42   |
| Anthracene, 80 per cent      | lb. | Nominal |       |
| Benzaldehyde (f.f.c.)        | lb. | 3.65    |       |
| Benzidine, base              | lb. | 1.75    | 2.00  |
| Benzidine, sulphate          | lb. | 1.40    | 1.50  |
| Benzonic acid, U. S. P.      | lb. | 3.10    | 3.25  |
| Benzoate of Soda, U. S. P.   | lb. | 2.90    | 3.00  |
| Benzyl chloride              | lb. | 2.60    | 2.70  |
| Beta naphthol benzoate       | lb. | 10.00   | 12.00 |
| Beta naphthol, sublimed      | lb. | .85     | .90   |
| Beta naphthylamine, sublimed | lb. | 2.65    |       |
| Diethyl benzal               | lb. | .15     | .20   |
| Diethylaniline               | lb. | 4.50    | 5.00  |
| Dinitro benzol               | lb. | .36     | .38   |
| Dinitrochlorobenzol          | lb. | .40     | .42   |



|                                |     |      |   |      |
|--------------------------------|-----|------|---|------|
| Dinitronaphthalene             | lb. | 55   | — | 60   |
| Dinitrotoluol                  | lb. | 65   | — | 75   |
| Dinitrophenol                  | lb. | 55   | — | 60   |
| Dimethylaniline                | lb. | 75   | — | 80   |
| Diphenylamine                  | lb. | 10   | — | 10   |
| H-acid                         | lb. | 2.70 | — | 3.00 |
| Metaphenylene diamine          | lb. | 1.75 | — | 2.00 |
| Monochlorobenzol               | lb. | 17   | — | 20   |
| Naphthalene, flake             | lb. | 00   | — | 09   |
| Naphthalene, balls             | lb. | 101  | — | 102  |
| Naphthionic acid, crude        | lb. | 1.20 | — | 1.30 |
| Naphthylamin-di-sulphonic acid | lb. | 1.00 | — | 1.20 |
| Nitro naphthaline              | lb. | 45   | — | 50   |
| Nitro toluol                   | lb. | 55   | — | 60   |
| Ortho-amidophenol              | lb. | —    | — | —    |
| Ortho-dichlor-benzol           | lb. | 15   | — | 18   |
| Ortho-toluidine                | lb. | 1.00 | — | 1.25 |
| Ortho-nitro-toluol             | lb. | 75   | — | 1.00 |
| Para-amidophenol, base         | lb. | 4.00 | — | 4.50 |
| Para-amido-phenol, H. Cl.      | lb. | 4.00 | — | 5.00 |
| Para-dichlor-benzol            | lb. | 15   | — | 20   |
| Paranitraniline                | lb. | 1.75 | — | 1.90 |
| Para-nitro-toluol              | lb. | 1.50 | — | 1.60 |
| Paraphenylenediamine (base)    | lb. | 3.75 | — | 4.00 |
| Para-toluidine                 | lb. | 2.00 | — | 2.25 |
| Phthalic acid anhydride        | lb. | 3.50 | — | 4.00 |
| Phenol, U. S. P.               | lb. | 44   | — | 46   |
| Resorcin, technical            | lb. | 5.00 | — | 7.00 |
| Resorcin, pure                 | lb. | 8.00 | — | 9.00 |
| S-sulvic acid                  | lb. | 8.00 | — | 1.10 |
| Salol                          | lb. | 1.50 | — | 2.00 |
| Sulphanilic acid, crude        | lb. | 2.50 | — | 3.2  |
| Tolidin                        | lb. | 2.50 | — | —    |
| Toluidine-mixture              | lb. | 85   | — | 90   |

### Petroleum Oils

#### Crude (at the Wells)

|                       |      |      |   |      |
|-----------------------|------|------|---|------|
| Pennsylvania          | bbl. | 4.00 | — | —    |
| Corning, Ohio         | bbl. | 2.85 | — | —    |
| Somerset, Ky          | bbl. | 2.60 | — | —    |
| Wooster, Ohio         | bbl. | 2.58 | — | —    |
| Indiana               | bbl. | 2.28 | — | —    |
| Illinois              | bbl. | 2.42 | — | —    |
| Oklahoma and Kansas   | bbl. | 2.25 | — | —    |
| Caddo, La., light     | bbl. | 2.25 | — | —    |
| Corcoran, Tex., light | bbl. | 2.35 | — | —    |
| California            | bbl. | 2.20 | — | —    |
| Gulf Coast            | bbl. | 1.35 | — | 1.57 |

#### Fuel Oil

|                |      |      |   |      |
|----------------|------|------|---|------|
| New York       | gal. | .11  | — | —    |
| Pittsburgh     | gal. | .07  | — | 10   |
| Oklahoma-Kans. | bbl. | 1.05 | — | 2.75 |
| Texas          | bbl. | 1.85 | — | 2.35 |
| Los Angeles    | bbl. | 1.60 | — | —    |
| San Francisco  | bbl. | 1.60 | — | —    |

#### Gasoline (Wholesale)

|               |      |      |   |   |
|---------------|------|------|---|---|
| New York      | gal. | .24  | — | — |
| Boston        | gal. | .25  | — | — |
| Pittsburgh    | gal. | .28  | — | — |
| Chicago       | gal. | .224 | — | — |
| Oklahoma      | gal. | .25  | — | — |
| San Francisco | gal. | .20  | — | — |

### Lubricants

|                                              |      |     |   |     |
|----------------------------------------------|------|-----|---|-----|
| Black, reduced, 29 gravity, 25-30 cold test. | gal. | .23 | — | .24 |
| Cylinder, light                              | gal. | .40 | — | .42 |
| Cylinder, dark                               | gal. | .39 | — | .41 |
| Paraffine, high viscosity                    | gal. | .40 | — | .42 |
| Paraffine, 903 sp. gr.                       | gal. | .35 | — | .38 |
| Paraffine, 885 sp. gr.                       | gal. | .25 | — | .27 |

### Flotation Oils

(Prices at New York unless otherwise stated)

|                                                                     |      |     |   |    |
|---------------------------------------------------------------------|------|-----|---|----|
| Pine oil, crude, f. o. b. Florida                                   | gal. | .44 | — | —  |
| Pine oil, steam-distilled, sp. gr. 0.925-0.940                      | gal. | 58  | — | 60 |
| Pine oil, destructively distilled                                   | gal. | 58  | — | 60 |
| Pine-tar oil, sp. gr. 1.02-1.035                                    | gal. | 35  | — | —  |
| Pine-tar oil, double refined, sp. gr. 0.965-0.990                   | gal. | 42  | — | —  |
| Pine-tar oil, ref., light, sp. gr. 0.950, tank cars, f. o. b. works | gal. | 37  | — | —  |
| Pine-tar oil, ref., heavy, sp. gr. 1.025, tank cars, f. o. b. works | gal. | 28  | — | —  |
| Pine-tar oil, ref., thin, sp. gr. 1.060-1.080                       | gal. | 32  | — | —  |
| Turpentine, crude, sp. gr. 0.870-0.900                              | gal. | 45  | — | —  |
| Hardwood oil, f. o. b. Michigan, sp. gr. 0.960-0.990                | gal. | 72  | — | —  |
| Hardwood oil, f. o. b. Michigan, sp. gr. 1.06-1.08                  | gal. | 23  | — | —  |
| Wood creosote, ref. f. o. b. Florida                                | gal. | 31  | — | —  |

### Vegetable and Other Oils

|                          |      |     |   |      |
|--------------------------|------|-----|---|------|
| China wood oil           | lb.  | .26 | — | .30  |
| Cottonseed oil, crude    | lb.  | .20 | — | .22  |
| Linsced oil, raw, cars   | lb.  | 76  | — | 1.82 |
| Peanut oil, crude        | lb.  | 36  | — | 1.37 |
| Rosin, oil, fat run      | gal. | 60  | — | —    |
| Rosin oil, fourth run    | gal. | 73  | — | —    |
| Soya bean oil, Manchuria | lb.  | 16  | — | —    |
| Turpentine, spirits      | gal. | .63 | — | .64  |

### Miscellaneous Materials

|                                     |         |         |   |       |
|-------------------------------------|---------|---------|---|-------|
| Barytes, floated, white, foreign    | ton     | 38.00   | — | 42.00 |
| Barytes, floated, white, domestic   | ton     | 32.00   | — | 36.00 |
| Becawax, white, pure                | lb.     | 42      | — | 43    |
| Casoin                              | lb.     | 14      | — | 28    |
| Chalk, light, precipitated, English | lb.     | Nominal | — | —     |
| China clay, imported, lump          | ton     | 20.00   | — | 40.00 |
| China clay, domestic, lump          | ton     | 15.00   | — | 22.50 |
| Feldspar                            | ton     | 8.00    | — | 12.00 |
| Fluorspar, gravel, f. o. b. mines   | ton     | 30.00   | — | —     |
| Fuller's earth, powdered            | 100 lb. | 1.50    | — | 2.00  |
| Graphite, flake                     | lb.     | 10      | — | 25    |
| Osokrite, crude                     | lb.     | 75      | — | 80    |
| Osokrite, American, refined, white  | lb.     | 85      | — | 90    |
| Red lead, dry, carlosite            | lb.     | 10      | — | 11    |

|                       |      |       |   |       |
|-----------------------|------|-------|---|-------|
| Rosin, 280 lb.        | bbl. | 11.00 | — | 12.60 |
| Soapstone             | ton  | 15.00 | — | 25.00 |
| Talc, American, white | ton  | 20.00 | — | 40.00 |
| White lead, dry       | lb.  | .091  | — | .101  |

### Refractories, Etc.

(F. O. B. Works)

|                                 |             |        |   |        |
|---------------------------------|-------------|--------|---|--------|
| Chrome brick                    | net ton     | 175.00 | — | —      |
| Chrome cement                   | ton         | 75.00  | — | —      |
| Clay brick, lat quality freelay | per 1000 50 | —      | — | 55.00  |
| Clay brick, second quality      | per 1000 50 | —      | — | 40.00  |
| Magnesite, raw                  | ton         | 30.00  | — | 35.00  |
| Magnesite, calcined, powdered   | ton         | 50.00  | — | 65.00  |
| Magnesite, dead burned          | net ton     | 50.00  | — | 60.00  |
| Magnesia brick, 9x4 1/2 x 2 1/2 | net ton     | 110.00 | — | 125.00 |
| Silica brick                    | per 1000 50 | —      | — | 60.00  |

### Ferroalloys

|                                                                               |     |        |   |        |
|-------------------------------------------------------------------------------|-----|--------|---|--------|
| Ferrocobaltititanium, 15-18 per cent, carloads, f. o. b. Niagara Falls, N. Y. | ton | 290.00 | — | 250.00 |
| Ferrocobaltium                                                                | lb. | 15.00  | — | 20.00  |
| Ferrocobaltium, per lb. of Cr                                                 | lb. | 5.25   | — | —      |
| Ferromanganese, domestic, 70 per cent basis                                   | ton | 250.00 | — | —      |
| Ferromanganese, English                                                       | ton | 325.00 | — | —      |
| Ferromolybdenum, per lb. of Mo                                                | lb. | 5.00   | — | —      |
| Ferrosilicon, 75 per cent, f. o. b. N. Y.                                     | ton | —      | — | —      |
| Ferrosilicon, 50 per cent, carloads, del. Pittsburgh                          | ton | 180.00 | — | 190.00 |
| Ferroalloy, 50 per cent, contract                                             | ton | 160.00 | — | 170.00 |
| Ferrotungsten, 75-85 per cent, f. o. b. Pittsburgh                            | lb. | 2.35   | — | 2.40   |
| Ferroumium, f. o. b. works, per lb. of U                                      | lb. | 7.50   | — | —      |
| Ferrovandanium, f. o. b. works                                                | lb. | —      | — | —      |

### Ores and Semi-finished Products

|                                                         |         |       |   |        |
|---------------------------------------------------------|---------|-------|---|--------|
| Antimony ore, per unit                                  | Nominal | 1.55  | — | —      |
| Chrome ore, 45 per cent minimum, f. o. b. Cal. per unit | ton     | 1.50  | — | 1.55   |
| Chrome ore, 45 per cent and over, New York, per unit    | ton     | —     | — | —      |
| Manganese ore, 48 per cent and over, per unit           | ton     | 1.20  | — | —      |
| Manganese ore, chemical                                 | ton     | 80.00 | — | 100.00 |
| Molybdenite, per lb. of MoS <sub>2</sub>                | lb.     | 1.25  | — | —      |
| Tungsten, Scheelite, per unit of WO <sub>3</sub>        | ton     | 24.00 | — | —      |
| Tungsten, Wolframite, per unit of WO <sub>3</sub>       | ton     | 24.00 | — | —      |
| Uranium oxide, 96%                                      | lb.     | 3.25  | — | 3.60   |
| Vanadium pentoxide, 99%                                 | lb.     | 10.50 | — | —      |
| Pyrites, foreign                                        | unit    | 17    | — | —      |
| Pyrites domestic                                        | unit    | 28    | — | 301    |

### Plant Supplies

#### BUILDING MATERIALS

|                                         |         |        |   |        |
|-----------------------------------------|---------|--------|---|--------|
| Common clay bricks                      | M       | 12.00  | — | —      |
| Hollow tile, 4 x 12 x 12                | M       | 96.00  | — | —      |
| Hollow tile, 12 x 12 x 12               | M       | 162.00 | — | —      |
| Lime                                    | ton     | 16.50  | — | —      |
| Portland cement                         | bbl.    | 2.59   | — | —      |
| Single glass (82-lb.), 10 x 26-16 x 24  | —       | 21.00  | — | 27.00  |
| Double glass (164-lb.), 10 x 26-16 x 29 | —       | 31.00  | — | 39.00  |
| Yellow pine lumber                      | M       | 39.00  | — | 45.00  |
| Fir lumber                              | M       | 38.00  | — | 53.00  |
| Hardlock                                | M       | 24.50  | — | 40.00  |
| Tarred felt (14-lb.-sq.)                | ton     | 64.00  | — | —      |
| Roofing pitch                           | ton     | 14.00  | — | 22.00  |
| Asphalt coated roofing (35-55-lb. sq.)  | sq.     | 1.30   | — | 2.50   |
| State surfaced asphalt shingles         | sq.     | 5.25   | — | 5.50   |
| Corrugated galvanized iron              | ton     | 109.00 | — | 127.00 |
| Red oxide (Ppte. Copperas)              | 100 lb. | 15.00  | — | 20.00  |
| Native red oxide                        | 100 lb. | 3.25   | — | 8.00   |
| Red metallic paint                      | 100 lb. | 1.20   | — | 1.50   |
| White lead oil                          | 100 lb. | 13.50  | — | 11.42  |
| Red lead oil                            | 100 lb. | 14.00  | — | 11.84  |
| Zinc oxide (dry)                        | 100 lb. | 13.00  | — | 14.50  |
| Zinc oxide, leaded                      | 100 lb. | 9.00   | — | 10.00  |
| Yellow ochre                            | 100 lb. | 1.50   | — | 10.00  |
| Ultra marine blue                       | 100 lb. | 14.00  | — | 50.00  |
| Prussian blue                           | 100 lb. | 135.00 | — | 150.00 |
| Chrome green                            | 100 lb. | 40.00  | — | 70.00  |
| Prus green                              | 100 lb. | 43.00  | — | 49.00  |
| Mineral black                           | 100 lb. | 1.75   | — | 2.25   |
| Powdered bone black                     | 100 lb. | 5.50   | — | 12.00  |
| Lampblack                               | 100 lb. | 15.00  | — | 45.00  |
| Gua carbon                              | 100 lb. | 16.00  | — | 25.00  |
| Mexican petroleum pitch                 | 100 lb. | 1.00   | — | 2.00   |
| Gilsonite                               | 100 lb. | 2.00   | — | 2.50   |
| Coal tar pitch                          | 100 lb. | 1.40   | — | 1.00   |

#### STRUCTURAL IRON

|                                   |     |        |   |        |
|-----------------------------------|-----|--------|---|--------|
| Blue annealed sheet iron          | ton | 85.00  | — | 87.00  |
| Black sheet iron                  | ton | 96.00  | — | 100.00 |
| Galvanized iron                   | ton | 105.00 | — | 125.00 |
| Tin and fern plate                | ton | 150.00 | — | 160.00 |
| Tank plates                       | ton | 70.00  | — | 80.00  |
| Beams, channels, angles, T's, Z's | ton | 60.00  | — | 65.00  |
| Rivets                            | ton | 92.00  | — | 105.00 |
| Steel pipe, 2 to 3-inch           | ton | 51.00  | — | —      |
| Bar iron and steel                | ton | 60.00  | — | 70.00  |
| Chain (1 inch proof coil)         | ton | 150.00 | — | —      |
| Nails, bolts, nuts, washers       | ton | 70.00  | — | 80.00  |
| Tool steel, special alloys        | ton | 300.00 | — | 500.00 |
| Bessemer pig iron                 | ton | 36.60  | — | —      |
| No. 2 foundry                     | ton | 34.40  | — | —      |
| Steel billets (4 x 4)             | ton | 47.50  | — | —      |

#### POWER HOUSE SUPPLIES

|                               |     |      |   |      |
|-------------------------------|-----|------|---|------|
| Steam packing, rubber duck    | lb. | 99   | — | 1.10 |
| Asbestos, high pressure       | lb. | 1.76 | — | —    |
| Asbestos, wired               | lb. | 1.30 | — | —    |
| Asbestos, graphited braid     | lb. | 1.21 | — | —    |
| Asbestos, wick                | lb. | .75  | — | —    |
| Rubber, sheet                 | lb. | .66  | — | —    |
| Cup grease                    | lb. | .07  | — | —    |
| Transmission grease           | lb. | .07  | — | —    |
| Axle grease                   | lb. | .041 | — | —    |
| Gear grease                   | lb. | .04  | — | —    |
| Cotton waste                  | lb. | .081 | — | —    |
| Hose, underwriters, 2 1/2 in. | ft. | 75   | — | —    |
| Hose, air, 2 in.              | ft. | 30   | — | —    |

# INDUSTRIAL NEWS

## Plant Construction—Catalogs—New Publications

### Construction and Operation

#### Arkansas

**HARRISON**—The Harrison Mining & Milling Co., located in Crooked Creek Valley Mining District, will rebuild its 75-ton mill recently destroyed by fire. The company is in the market for sludge and slime tables, belts, mill hardware, mill lumber, and air compressors. Estimated cost, \$18,000. George Constant, Harrison, superintendent.

**MENA**—The Abbott, Rebholz and Stewart Mining Co., Baxter Springs, Kan., will build a concentration plant here. Estimated cost, \$25,000. The company is in the market for steam shovel, crushers, washers, belts, cars, engine and boiler. J. I. Abbott, superintendent.

**MOUNTAIN HOME**—The Mattie May Mining Co. will build a 150-ton concentration plant and is in the market for sludge and slime tables, engines, boilers, crushers, air compressors, lumber, mill hardware, roofing, piping, belts and cables. Estimated cost, \$40,000. E. Zimmerman, superintendent.

**BATESVILLE**—The Vance Mining Co. will build a 100-ton concentration plant and is in the market for steam shovel, cars, track, log washer, lumber, mill hardware, engine and boiler. Estimated cost, \$25,000. C. H. Plumb, Miners Bank Bldg., Joplin, Mo., superintendent.

#### Alabama

**ASHLAND**—The Grisesmer Graphite Co. will rebuild its concentration plant recently destroyed by fire. Estimated cost, \$75,000. F. C. Hooper, Ashland, superintendent.

#### Arizona

**AJO**—The New Cornelia Copper Co. will build a flotation plant for the care of new ore production, and will later build a smelter.

**WALKER**—The Black Diamond Mining & Development Co., Prescott, will build a concentration and flotation mill and install machinery for same. Estimated cost between \$10,000 and \$15,000. J. Irwin, P. O. Box 463, Prescott, superintendent.

#### Connecticut

**NEW HAVEN**—Yale University will build a 5-story, 100 x 100 ft., reinforced concrete, brick and steel laboratory. Estimated cost, \$300,000. Day & Klauder, 925 Chestnut St., Philadelphia, Pa., architects.

**PUTNAM**—The Manhasset Manufacturing Co., 33 Canby St., has awarded the contract for the construction of a 2-story, 40 x 100 ft., concrete and brick factory, for the manufacture of tires, to Torrington Building Co., 19 North St., Torrington. Estimated cost, \$40,000.

#### Illinois

**CHICAGO**—The Symington - Chicago Corporation, 122 South Michigan Ave., has awarded a contract for the construction of a 1- and 2-story brick and steel munition plant on Seventy-fourth and Ashland sts. to Thompson-Starratt Co., 175 West Jackson St. Cost between \$5,000,000 and \$6,000,000.

**HEGEWICH**—The General Chemical Co., 25 Broad St., New York City, has awarded the contract for the construction of a 120 x 140 ft. factory building, to the Austin Co., 16112 Euclid Ave., Cleveland, O.

#### Kansas

**BAXTER SPRINGS**—The Chitto Lead & Zinc Co. will build a 250-ton concentration plant. Estimated cost, \$45,000. The company is in the market for oil engine, lumber, mill hardware, sludge tables, air compressors, belts and crushers. Frank Chitto, Baxter Springs, superintendent.

**BAXTER SPRINGS**—The Cook & McCulloch Mining Co. will build a 150-ton concentration plant, and is in the market for sludge and slime tables, crushers, air

compressors, conveyors, air pipes, belts, jigs, drills, ore cars, track, engines, boilers, lumber, mill hardware and concrete for mill bases. Estimated cost, \$40,000. W. McCulloch, Baxter Springs, superintendent.

**BAXTER SPRINGS**—The Euterpe Mining Co. will remodel its 200-ton concentration plant and is in the market for roofing, lumber, belts, conveyors, hardware, sludge tables, drills and crushers. Estimated cost, \$35,000. C. Clark, superintendent.

**CRESSWELL**—Frank Nicholson and Frank Harrington, 202 Sargent St., Joplin, Mo., will build a 150-ton concentration plant at their mine here, and are in the market for mill machinery, lumber, hardware, oil engine, sludge and slime tables, crushers, ore cars, ore bins and air compressors. Estimated cost, \$33,000. O. W. Sparks, superintendent.

**TRECE**—The Miami-Texas Mining Co. will remodel its 250-ton concentration plant here. Estimated cost, \$25,000. The company is in the market for lumber, belts, sludge and slime tables, rollers for crushers, air compressors, conveyors, ore cars, and track. F. W. Stallings, Trece, superintendent.

#### Louisiana

**NEW ORLEANS**—The Bureau of Yards & Docks, Navy Department, Washington, D. C., will build four ammunition plants here. Estimated cost, \$4,500.

#### Maryland

**BALTIMORE**—The city will enlarge the filtration plant at Lake Montebello, build an additional filtered water reservoir and also a plant for the manufacture and storage of alum. W. E. Le Clair Hall, water engr.

**CUMBERLAND**—The American Colulose Co., 52 Vanderbilt Ave., New York City, has awarded the contract for the construction of a 1-story plant for the manufacture of cellulose for war purposes to G. A. Fuller, Fuller Building, New York City. Estimated cost, \$10,000,000.

**CURTIS BAY** (Baltimore P. O.)—The Curtis Bay Copper & Iron Works will build three-story, 70 x 120 ft. steel and hollow-tilt additions to its plant here, machine shop type. W. F. Cochrane, South Baltimore, engineer.

**INDIAN HEAD**—The Bureau of Yards & Docks, Navy Department, Washington, D. C., will build a nitrate plant here. Estimated cost, \$9,000,000.

**INDIAN HEAD**—The Bureau of Yards & Docks, Navy Department, Washington, D. C., has awarded the contract for the remodeling of chemical laboratory at the Naval Station here, to Austin Co., 1626 Bulletin Building, Philadelphia, Pa. Estimated cost about, \$25,000. Noted June 30.

**INDIAN HEAD**—The Bureau of Yards & Docks, Navy Department, Washington, D. C., has awarded the contract for the construction of a chemical laboratory here, to Austin Co., 1313 H St., N. W., Washington, D. C. Estimated cost, \$25,350.

#### Michigan

**GRAND RAPIDS**—The Volvorne Brass Works, Monroe Ave., will build a 5-story addition to its plant. Osgood & Osgood, architects.

#### Missouri

**GRANBY**—The Carolyn Metal Co., Oklahoma City, Okla., will remodel and increase the capacity of its 150-ton mill to 250 tons, and is in the market for sludge and slime tables, roofing lumber, crushers, belts and air compressors. Estimated cost, \$25,000. N. Darling, superintendent.

**GRANBY**—E. L. Plank, Everitt Smith and E. R. Rashley, will build a 150-ton concentration plant at their mine here, and are in the market for sludge and slime tables, roofing engine, ore cars, crushers, lumber, mill hardware, air compressors and conveyors. Estimated cost, \$55,000. E. L. Plank, superintendent.

**JOPLIN**—The Badger Mining Co. will build a 250-ton concentration plant and is in the market for sludge and slime tables, engine, boilers, belts, crushers, lumber,

mill hardware, ore tubs, ore cars, track, rope, and roofing. Estimated cost, \$60,000. A. Foster, 401 Miners Bank Building, manager.

**JOPLIN**—The Rashgo Mining Co., will build a 150-ton concentration plant near the Sunnyside Mine, and is in the market for sludge and slime tables, crushers, air compressors, lumber, mill hardware, conveyors, belts, track and cars. Estimated cost, \$15,000. W. M. Randell, Joplin, superintendent.

**ORONOGO**—A. F. Hott will rebuild the 200-ton concentration plant at his mine, recently destroyed by fire, and is in the market for sludge and slime tables, oil engine, belts, air compressors, rollers, mill hardware, drills and ore crushers. Estimated cost, \$25,000.

**SENECA**—The Mt. Nebo Lead & Zinc Co. will build a 200-ton concentration plant, and is in the market for mill lumber, mill hardware, belts, cables, ore cans, sludge and slime tables, ore crushers, conveyors, air compressors, boilers and engine. Estimated cost, \$40,000.

**ST. LOUIS**—The Mousanto Chemical Works, 1800 South Second St., will build an addition to its plant. Brenneke & Pay, 1000 North Third St., engineers.

**ST. LOUIS**—The Moon Motor Car Co., 4401 North Main St., has awarded the contract for the construction of a 4-story, 50 x 126 ft., reinforced concrete, munition factory, to Greve Construction Co., Century Building. Estimated cost, \$48,000. Noted June 15.

**ST. LOUIS**—The Scullin Steel Co., 6700 Manchester St., has awarded the contract for the construction of a 2-story, 41 x 283 ft., reinforced concrete, brick and steel munition plant at 2514 Ecoff St., to Crowell, Lundorff, Little Co., 1951 East Fifty-ninth St., Cleveland, Ohio. Estimated cost, \$200,000.

**WACO**—The Blue Rock Mining Co. will build a 250-ton concentration plant and is in the market for slime and sludge tables, crushers, conveyors, air compressors, lumber, mill hardware, roofing, engine and boilers. Estimated cost, \$60,000.

**WACO**—The Miami-Waco Lead & Zinc Co. will build a 250-ton concentration plant requiring ore crushers, engine, compressors, rollers, and sludge and slime tables. The slime tables, belts, lumber, ore cars and track. Estimated cost, \$40,000. W. P. Cunningham, Waco, superintendent.

**WACO**—The Central Zinc Co. will remodel the 400-ton mill which it recently purchased and install mill hardware, lumber, sludge tables, air compressors, rollers, ore crushers, boilers, ore cars and track. Estimated cost, \$20,000. Frank Dangleade, Waco, superintendent.

**WACO**—The Crescent Lead & Zinc Co. will build a 250-ton concentration plant. Estimated cost, \$35,000. The company is in the market for gas shovels, rollers, air compressors, rollers, tables, jigs and mill hardware. Glen Smith, Waco, superintendent.

#### New Jersey

**BLOOMFIELD**—The International Arms & Fuse Co., Bloomfield Ave., will build a 3-story, 75 x 100 ft. addition to its plant.

**HARRISON**—The Crucible Steel Co., Sixth Fourth St., has awarded the contract for the construction of a 1-story, 70 x 100 ft. rolling mill, to W. H. & W. Cane, Woolworth Building, New York City. Estimated cost, \$500,000.

**JERSEY CITY**—The Metal & Thermit Corporation, 527 Johnston Ave. it recently built a 1-story, 35 x 100 ft. steel plant. Estimated cost, \$15,000.

**KEARNBY** (Arlington P. O.)—Henry Field, Detroit, Mich., will build a 1-story, 400 x 1100 ft., brick and steel cetry on the Passaic River here for the construction of patrol boats and submarine chasers. Estimated cost, \$2,000,000.

**NEWARK**—The Fetterworth-Judson Co., 1000 Broad St., will build a 40 x 84 x 60 ft., brick and steel chemical plant. Estimated cost, \$118,000.

**NEWARK**—The E. I. duPont de Nemours & Co., duPont Building, has awarded the contract for the construction of a 1-story, 28 x 49 ft. and 2-story, 28 x 103 ft., brick factory buildings, to G. Tomlinson & Son, 2619 South 12th St., Philadelphia, Pa. Estimated cost, \$27,150.

#### New York

**RUFFALO**—The Atlas Steel Castings Co., 1963 Elmwood Ave., has awarded the contract for the construction of a 1-story, 30 x 200 ft. plant, to the Austin Co., 16112 Euclid Ave., Cleveland, O.



**BUFFALO**—The Linde Air Products Co., 155 Chandler St., has awarded the contract for the construction of a 1-story plant on Fillmore Ave., to J. W. Cowper Co., Fidelity Building. Estimated cost, \$10,000.

**CHATEAUGAY**—The High Falls Pulp & Paper Co. will build a 1-story, reinforced concrete and brick pulp and paper mill. Estimated cost, \$75,000. Thompson & Henger, Gurney Building, Syracuse, engineers.

**HASTINGS**—The Cantonment Division, War Department, Washington, D. C., will build a large chemical plant here for the use of the Ordnance Department. First unit to cost, \$500,000.

## Olio

**CLEVELAND**—The Great Western Oil Co., 2846 East Thirty-seventh St., will build an oil refining plant to replace the one recently destroyed by fire. W. W. Hodges, Snodell Building, architect.

**CLEVELAND**—The Lakeside Hospital, Lakeside Ave. and East Twelfth St., has awarded the contract for the construction of a 2-story, 42 x 62 ft., brick and concrete addition to the laboratory, to Crowell, Lundoff, Little Co., 1951 East Fifty-seventh St. Estimated cost, \$20,000.

## Oklahoma

**CENTURY**—The Crescent Mining Co. will build a 200-ton concentration plant. Estimated cost, \$45,000. The company is in the market for sludge and slime tables, crushers, conveyors, air compressors, jigs, belts, mill hardware, mill lumber, roofing, engine and cables. H. L. Woods, Commerce, superintendent.

**COMMERCE**—The Big Jim Mining Co. will build a 200-ton concentration plant. The company is in the market for mill lumber, roofing, sludge and slime tables, mill hardware, engine, crushers, air compressors, jigs and conveyors. Estimated cost, \$60,000. G. W. Nesmith, Commerce, superintendent.

**COMMERCE**—The Miami Volunteer Mining Co., Miami, will remodel and enlarge its 200-ton concentration plant, which is in the market for sludge and slime tables, oil engine, belts, mill hardware, lumber and crushers. Estimated cost, \$25,000. J. L. Hawthorne, Tulsa, Okla., superintendent.

**DOUTHAT**—J. J. McElahan and Ray Munson will build a 500-ton concentration plant at their mine and are in the market for sludge and slime tables, jigs, cleaner, crushers, lumber, hardware, engine and rollers. Estimated cost, \$65,000. Ray Munson, Douthat, superintendent.

**HOCKERVILLE**—McCurdy Bros. Mining Co., Quapaw, will build a 200-ton concentration plant and is in the market for sludge and slime tables, mill hardware, rollers, engine, air compressors, conveyors and crushers. Estimated cost, \$65,000.

**HOCKERVILLE**—The Tulsa-Sulphur-Miami Associated Mines Co. will build a 200-ton concentration plant and is in the market for sludge and slime tables, crushers, pipes, lumber, hardware, air compressors, conveyors, roofing and engine. Estimated cost, \$65,000.

**LAWTON**—The Development Co. will remodel its concentration plant increasing the capacity from 250 tons to 500 tons and is in the market for sludge and slime tables, air compressors, rollers, pipes, rollers, crushers, mill hardware, mill lumber, and ore cars. Estimated cost, \$10,000. E. E. Jancy, Lawton, superintendent.

**LINCOLNVILLE**—The White Swan Coal Co. will build a 200-ton concentration plant at its mine here. Estimated cost, \$85,000. The company is in the market for sludge and slime tables, mill lumber and hardware, air compressors, rollers, engine, rollers, engine and rollers. J. H. Stoddard, West Plains, Mo., superintendent.

**OKMUTGEE**—The city will build a filtration plant, sewage disposal plant and new main sewer. Estimated cost, \$150,000. Burns & McDonnell, 402 Interstate Building, Kansas City, Mo., engineers.

**QUAPAW**—The Allied Lead & Zinc Co. will remodel its 250-ton concentration plant and is in the market for sludge and slime tables, mill hardware, belts and compressors. Estimated cost, \$15,000.

**QUAPAW**—The Lead Cave Mining Co. will remodel its 200-ton concentration plant and install sludge and slime tables, new belts, cables, track, rope, roofing, lumber and hardware. Estimated cost, \$60,000.

**QUAPAW**—The Six Mining Co., Miami, will build a 600-ton concentration plant and

is in the market for sludge and slime tables, roofing, mill hardware, lumber, crushers and engine. Estimated cost, \$65,000.

**QUAPAW**—The Spelter Mining Co. will build a 200-ton concentration plant east of Quapaw. The company is in the market for sludge and slime tables, crushers, lumber, roofing and hardware. Estimated cost, \$65,000.

**TAR RIVER**—The Maxine Co. will build a 400-ton concentration plant. Estimated cost, \$85,000. The company is in the market for a gas drying engine, crushers, air compressors, belts, lumber, roofing, conveyors, mill hardware, sludge and slime tables, etc. W. C. Miller, Tar River, superintendent.

## Pennsylvania

**CHESTER**—The Crown Smelting Co. will build a 1-story, 17 x 100 ft., addition to its pattern works.

**ERIE**—City plans to build intercepting sewers and sewage treatment works. Estimated cost, \$300,000. Chester & Fleming, Union Bank Building, Pittsburgh, engineers.

**JANCASTER**—The Bottonfield Tire Co., Woolworth Building, will build an addition to its plant. Estimated cost, \$10,000. H. R. Evans, 104 East Orange St., architect.

**MARCUS HOOK**—The National Aniline & Chemical Co., Inc., has awarded the contract for the construction of oxide pits, to the Austin Co., 16112 Euclid Ave., Cleveland, Ohio.

**SACKETTOWN**—The Midvale Steel Co., Widener Building, Philadelphia, will build a 1-story, 113 ft. 8 in. x 48 ft. rough machine shop, a 1-story, 74 ft. 11 in. x 36 ft. 6 in. heat treatment plant, and a 1-story, 183 x 362 ft. finish machine shop, all buildings to be of steel construction.

## Rhode Island

**BRADFORD**—The Bradford Dyeing Association will build a 1-story, 69 x 200 ft., brick and timber mill building. Estimated cost, \$20,000. Jenks & Ballou, Grosvenor Building, Providence, engineers.

## Tennessee

**KINGSFORD**—The Cantonment Division, War Department, Washington, D. C., will build a large chemical plant here for the use of the Ordnance Department. First unit to cost, \$500,000.

## Texas

**CULBERSON CO.**—Edward Hart, Bartow, and others, will build a plant for refining raw sulphur and for the manufacture of sulphuric acid.

**FT. WORTH**—The city will build a sewage disposal plant. A. Lord, waterworks commissioner.

**WACO**—The city plans to build a sewage disposal plant. Rollen J. Windrow, city engineer.

## Virginia

**HAMPTON**—The Bureau of Yards & Docks, Navy Department, Washington, D. C., will build an addition to the laboratory here. Estimated cost, \$13,000.

**KERMIT**—The Carroll Development Co., 312 McMain Building, Roanoke, Va., will build a plant here for developing silica deposits. E. A. Schubert, president.

## Washington

**SEATTLE**—The Northwest Motor Co., 618 East Pike St., will build a 90 x 250 ft. steel foundry for the production of iron and steel on industrial sites 6 and 7, King Co. Estimated cost, \$150,000.

The Quilley Furnace Specialty Company, Inc., has opened a branch office in Pittsburgh at 427 Ohio Building, to handle the sale of powdered coal equipment, and Hytemple furnace cement. The powdered coal engineering department will be in charge of Mr. V. Mayo, formerly maintenance engineer of the A. M. Byers Company plant at Girard, Ohio, and the specialties department will be taken care of by Mr. J. L. Cummings, Jr., formerly connected with the sales department of the company at New York.

The Electric Furnace Construction Co., Philadelphia, recently placed in operation a 3-ton electric furnace of the Greaves-Etchells type at the plant of the Ford Motor Co., Detroit. It is operating on nickel-chrome steel for special airplane

work, producing heats in as low as 11 hours. There are a number of electric furnaces in operation but this is the first one of the type to be placed in operation in the United States. The following furnaces will be placed in operation: Two 3-ton furnaces at the plant of the Halcomb Steel Co., Syracuse, N. Y.; one 6-ton furnace at the Navy Yard, Puget Sound, Wash., and two 6-ton furnaces at the plant of the American Radiator Co., Buffalo, N. Y.

The Electric Furnace Industries War Service Committee has been organized by manufacturers of electric furnaces for the purpose of operating electric furnaces. It is apparent that there may be a need for the same. Its object is to compile and furnish information to the Government relative to electric furnace industries in the production of steel, ferrous and non-ferrous alloys, and metals where the melting problem is concerned. The following manufacturers have become members of the new organization: Hamilton & Hansell Co., New York; John A. Crowley Company, New York; Ajax Metal Company, Philadelphia; American Metallurgical Corp., Philadelphia; Electric Furnace Construction Co., Philadelphia; Pittsburgh Furnace Company, Pittsburgh; Booth-Hall Furnace Company, Chicago, Ill.; Industrial Electric Furnace Co., Chicago, Ill.; Electric Furnace & Co., New York City; Ludlum Electric Furnace Co., Woodworth Bldg., N. Y.; T. W. Price Engineering Company, New York; Beckman & Linden Corp., San Francisco, Cal.

The Wellman-Seaver-Morgan Co., Cleveland, O., has recently ordered from the H. Koppers Co. five coke pushers for the John Hancock Co., and has ordered the installation in Fairmount, W. Va. A coke pusher is also ordered for the Wipulotte Coke Oven Corporation, New York.

The Island Petroleum Co., and the Concrete Products Co., whose plants are on Seville Island, Esfuerzo, P.R., have been notified by the Government that their properties are wanted for the United States Steel Corporation's new gun and projectile plant. They have been advised that while immediate ownership is desired by the Government, actual possession is not wanted at once and they will be given enough time to remove their plants to other locations. The Witherow Steel Co., another plant on Seville Island, has been notified by the Government not to make additional improvements to the plant. It is wanted by the Government and all manufacturing plants on it will have to seek other locations.

The Cleveland Furnace Co., Cleveland, Ohio, is refining its No. 2 furnace and making other improvements to its plant which will include the building of a ladle-cleaning house, the installation of a new pig-casting machine and enlarging the furnace hearth from 15 to 18 ft., which will increase the daily capacity of the stack from 400 to 500 tons.

The Samson-Sieve Grip Tractor Co., Sacramento, Cal., is installing a 5-ton Heroult electric furnace to make steel castings.

The Enterprise Foundry, South San Francisco, Cal., has recently installed an electric furnace of its own design.

The T. W. Price Engineering Co., Inc., has just sold a 5-ton vom Bau electric furnace with bars bottom to the Hercules Steel Casting Co., Inc., Milwaukee, Wis., which is expected to be in operation by October.

The Mesta Machine Co., Pittsburgh, Pa., has placed a contract with the Smith Gas Manufacturing Co., Dayton, Ohio, for gas producers, which will be equipped to furnish 10,000 cu. ft. of producer gas every 24 hr. of 14 to 15 Btu. per cu. ft. for use in the gas plant at Mesta, Pa., near Pittsburgh, to replace both fuel oil and natural gas. The equipment will be installed in eight units, each capable of producing about 350 cu. ft. of bituminous coal per hr. The first four units installed are expected to be completed during the coming winter, the other four will be built later.

Standardization of Catalogs.—The National Association of Purchasing Agents has adopted a page measuring 7 1/2 by 10 1/2 inches as the standard size for catalogs which will be furnished to the members of the association. The new size for catalogs has been adopted by the National Retail Hardware Association and the National Association of Brass Manufacturers. The adoption of manufacturers is urged for bringing about the standardization of catalogs.

The Dorr Company will move its New York office from 17 Battery Place to the Architects Building, 101 Park Avenue, corner of 40th Street.



# CHEMICAL & METALLURGICAL ENGINEERING

A consolidation of ELECTROCHEMICAL & METALLURGICAL INDUSTRY and IRON & STEEL MAGAZINE

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### Match Your Patriotism

#### Against the National Army Men

A PROGRESSIVE and trustworthy employer of a large amount of labor in a middle western metallurgical industry states that while the average wage had increased 48 per cent over that paid immediately preceding the war, the cost of getting the same work done had risen 67 per cent owing to an actual decrease in efficiency of the higher-paid labor. This is startling enough, but far more impressive when contrasted with the spirit existing for instance in our flying schools, where as one cadet put it, "If anyone had asked me to work half as hard in civil life for double the pay I would have laughed at him."

Un-Americanism infiltrates throughout industry; pure Americanism is rampant among our flyers. Industry is packed with immigrants foregathering in unlovely settlements, stewing in ignorance and squalor, this mass being more or less feebly leavened with native unionists bred with limitation-of-output ideas and superintended too often by "slave drivers" pure and simple. On the other hand, our flyers are gathered from our colleges, universities and technical schools, those institutions at once the child and mother of liberty, and are officered by self-sacrificing patriots and scholars. One's pride in our soldiers matches illy his apologetic toleration of wage- and business-profiters.

As recent events show, we Americans need a rude jolt to waken us—a tinkling alarm cannot penetrate our complacent superficiality, our inability to pursue an idea to its ultimate conclusion. For instance, in response to early warnings of impending fuel famine, New York City darkened Broadway! Officialdom also seems to bow to the great American ego when it exempts taxi-drivers from the "Work or Fight" order. We adopted the selective draft because we knew that volunteering in mass would not follow war's declaration. We are too heterogeneous to act with unanimity: scant majorities rule. Yet we could not bring ourselves to the equally obvious draft of the production indispensable to maintain our growing army. Too many manufacturers refuse munition orders at 15 per cent profit when peace orders net many times more. Priorities may force a change of heart; lack of coal, lack of steel, lack of transportation, will doubtless temper "business patriotism."

But how can we bring workers into shipyards, munition works, food production? How impress them with the idea, as William Hard puts it, that it is just as wrong to abandon a gun-carriage which is being made to kill Germans as to abandon a gun-carriage which is killing Germans? Conscription of labor—the corollary of conscription of fighters and the conscription of industries—naturally is not popular with the workers.

even though it is virtually in effect under the provisions of the selective draft which allows industrial exemption. Yet any class should realize that a draft is surely coming unless the impossible ensues, unless they volunteer *en masse*. As far as the native worker is concerned, the impossible might be possible, if he were sure that the sacrifice of his present status would not redound to the employers' immeasurable profit.

Here a campaign of education would help; indeed where would it not help? For instance, the employers might well recognize the fact that they may tardily institute Americanization classes among the immigrants they are largely responsible for, seriously endeavor to improve working, housing and cultural surroundings of their workers, and seek by every means possible an *entente cordiale* between all parts of their organization.

Employer and employee alike must give and not grasp. Give until it hurts, even to surrendering conflicting "rights." Match patriotism and sacrifice with the sacrifice of the national army men, and you, as they, will be new born, will gain more than lose, and emerge better and cleaner citizens of America.

### Germany's Finger in the Platinum Pie

FIRST let us dig up a little history. Thirty years ago the world's headquarters for platinum were with Johnson, Matthey & Co., Ltd., of London. Then, following the path of trade in many other branches of industry, the Germans took a hand and there arose one Heraeus, who became a man of might. The American manufacturing business was promising but undeveloped, although it started here. There was the Bishop concern in Pennsylvania and Baker & Co. of Newark, both small, the latter also refining gold and silver from jewelers' sweepings, photographers' residues, etc. In the meantime an understanding appears to have been reached between Heraeus in Germany and Johnson, Matthey & Co. in England.

Next we observe the organization of the American Platinum Co. of Newark, and find Mr. Charles Engelhardt in control, seconded in time by his able assistant, Dr. Zimmermann, a reserve officer of the German army. Mr. Engelhardt also came from Germany, but whether he was sent here as an agent of Heraeus or came independently we do not know. Soon the Baker establishment began to expand, far beyond the means and credit presumably available to the firm as it was, and they proceeded to make platinum stills for sulphuric acid and other apparatus on a large scale. We do not affirm that these extensions were paid for by German capital, we merely state our understanding that a large percentage of the stock was soon owned by Heraeus and Engelhardt on the one hand and an equal share by Johnson, Matthey & Co. on the other. Heraeus also is said to have owned a one-fifth interest in Johnson, Matthey & Co.

Shortly after the enlargement of the Baker concern and the accession of new interests, the price of platinum advanced out of all proportion; far higher than trade conditions warranted. The situation displayed all the stigmata of the presence of a regular, old-fashioned, millions-in-it trust. The senior Baker died and so did one of his sons, leaving Cyrus O. and Charles in the business. Now Cyrus also is dead, and while Charles

still participates in it, the platinum headquarters in America are to be found under Mr. Charles Engelhardt's hat and not elsewhere. In the meantime Baker & Co., Inc., are reported to have gone into the manufacture of platinum jewelry mountings on a large scale.

The complexities of German ownership grew apace. There was the Croselmire concern which was originally a gold and silver refinery similar to the original Baker house, and a competitor. This was taken over by Roessler & Hasslachner who proceeded to offer platinum and platinum compounds for sale. Roessler & Hasslachner are or were connected with and established by the Deutsche Gold & Silber Scheideanstalt at Frankfurt on the Main. What the relations between the Scheideanstalt and Heraeus are we do not know, but the disposition of German houses is to be friendly in foreign trade. Neither can we give the relations between the corporations named and other refiners of the metal in this country except to note that the trade seems to be closely organized.

Whatever the original composition of the international platinum syndicate, it is evident that Johnson, Matthey & Co. dropped out when the war began and they have had to shift for themselves. We are informed that Mr. Engelhardt and his friends have taken over the Heraeus interests in the American organizations. He is, we understand, an American citizen, and he has functioned as the advisor in regard to the metal with which he is abundantly familiar, to the Division of Chemistry of the War Industries Board. The chairman of this department is Mr. L. L. Summers. And here we reach a situation that we would like very much to have explained.

Mr. F. W. Draper brought over from Russia for sale 20,000 ounces of platinum which was the property of the Russian and English Bank. He was authorized to sell it for \$105 an ounce. On the arrival of the metal in New York it was commandeered by the War Industries Board. There followed a series of interviews between Messrs. Summers and Draper, in which Mr. Summers offered to pay \$90 an ounce for it and no more and refused to let it be sold elsewhere. Mr. Draper protested and so did the Bank, claiming that this would involve the institution in serious financial loss, but \$90 an ounce is all they received. Mr. Draper said that the bank had 15,000 ounces more for sale and that at the time they were able to produce and deliver still more, but it is also said that after the \$90 episode they gave up the idea of sending any more platinum to the United States. Now if the German interests wanted to prevent the metal from reaching this country so as to make us slow down on the production of the needed *plum* for munitions they could not have asked for a more effective means to accomplish their purpose.

The present situation is that we need more platinum than there is in sight. That is a fact and we are not interested in the opinions of laymen as to what substitutes are available for various purposes or what the effect of such steps as may be necessary will be upon the 1918 profits of the jewelry trade. What we would like to know is whether Mr. Summers cut the price for Mr. Draper from \$105 to \$90 on the advice of Mr. Engelhardt or on his own initiative. If it was wholly on his own initiative it was a blunder—but we all make mistakes. On the other hand, if it was at the

suggestion or on the advice of Mr. Engelhardt, who is too well posted on platinum affairs to make serious errors in calculation, it will establish in us the fear that he is still a little too close to the Heraeus outfit to be an entirely safe advisor in time of war.

There has been too much talk and too little doing in this matter. It is amazing to consider that serious men will listen to the effort to balance up fashions and styles in jewelry with the country's need in its hour of peril. There is just one way out of this difficulty and that is for the U. S. Government to take control and possession of every plant that handles platinum and proceed to order sales according to requirements.

The Committee on Ways and Means spent the better part of three days listening to the views of jewelers, chemists and Government representatives on the platinum situation. While the committee was not enlightened on the question of how to raise revenue from platinum, it did receive considerable information which Congress as a whole might read to its profit. By far the best advice the committee received was that there should be no platinum to tax; that the Government should gather into its vaults all platinum not now serving a useful purpose in war work and hold it against the time when it may be needed.

### **Increasing Production of By-Product Coke**

UNDER pressure of war demand for explosives, first by the Allies and then by the United States Government, there is no end to the building of by-product coke ovens. An astonishing showing is being made for these days of high construction costs. The more important items of by-product oven completion are 140 ovens put in operation at Gary early in the year; 180 ovens at Cleveland (American Steel & Wire Company), which made their first coke in May and are now in full operation; 128 ovens at Clairton (Carnegie Steel Company), which made their first coke late in June and are now in full operation, with four similar batteries of 128 ovens each to be completed at various times to December 31; 208 ovens at Lorain, O. (National Tube Company), half of which are now in operation, with the other half to be completed in 30 to 60 days; and 102 ovens at Youngston (Youngston Sheet & Tube Company), half completed and half to be completed in 30 to 60 days. Smaller completions are 65 ovens of the Minnesota By-Products Company, 24 of the Chattanooga Coke & Gas Company and 60 of the Bethlehem Steel Company at Steelton, Pa. The ovens completed this year to date represent about 3,000,000 net tons a year in actual coke production and the ovens still to be completed this year approximately as much, perhaps somewhat more, possibly somewhat less. In addition there are many projects that have been on the way for some time, together with a fresh batch inaugurated within the past three months, in some of which Government financing is involved, the builders to take the ovens from the Government after the war at an appraised valuation.

For an industry growing so rapidly the annual production reports of the Geological Survey are only of general value, for the reported production of a year does not indicate the capacity at either the beginning or end of the year or even the average capacity for

the year. The weekly reports which were instituted at the beginning of this year prove quite illuminating. They show that while the rating of a plant's capacity is done with more or less skill and definite knowledge, it varies from time to time. The reports show for each week both the rated capacity and the actual production. At a number of plants the ratings have varied according to the kind of coal they were using. During the railroad blockade of last winter some were forced to take coal that was not their choice, and their ratings were below normal for the plant. The rated capacity at the beginning of the year, given the choice of coal, was about 500,000 net tons a week. When operations became what may be considered substantially "normal," production turned out to be rather regularly about 90 per cent of rated capacity, there being an average sprinkling of plant repairs, little interruptions in coal supplies, labor difficulties, etc., that accounted for 10 per cent.

The first week in July a landmark was passed, the output for the first time being a half million tons; 502,666 tons, to be exact, with a rated capacity for the same week of 556,592 tons. There had been such an increase in the half year that the expected production, under normal conditions, would be increased by very nearly 50,000 tons, or fully 10 per cent in the course of six months. Starting the year with a rated capacity of 500,000 tons a week the industry promises to end it with about 615,000 tons capacity, from which it may be said that the expected production, at 90 per cent of rated capacity, promises to increase from 450,000 tons a week to fully 550,000 tons a week; and 1919 will show its own further increases. The rate of production at the close of 1918 should be nearly 30,000,000 net tons a year, against 22,600,900 tons actually produced in 1917. Assuming the actual production in 1918 to be 26,000,000 tons, which seems a fair guess, it may be said that in 1914, four years earlier, the output was not one-half as great; in 1909, nine years earlier, it was not one-quarter as great; in 1904, 14 years earlier, it was not one-eighth as great.

Of course there remains a great loss in volatile elements by the fact that the beehive process is still the predominating one. The weekly output of beehive coke, unlike that of by-product coke, varies so widely that a precise statement cannot be made of the average rate of production, but the average of the latest six weeks for which there are statistics at this writing shows a weekly average of 620,000 tons. To what extent the increase in by-product coke production will decrease the beehive production remains to be seen. Conditions are somewhat confusing and it is impossible to determine just how much coke the blast furnaces and other consumers will require. Much of the coal, moreover, that is used in by-product coking is drawn from beehive coking regions, and if the supply of coal controls, the beehive ovens will be closed when by-product ovens are completed, even though the preference would be to operate both. The balance of probability seems to be that if the by-product industry reaches a rate of actual production of 600,000 tons a week by the end of the year, the production of beehive coke will have dropped to less than 600,000 tons, so that then by-product coking will at last predominate. At August 1 the proportions seemed to stand about 55 to 45.



## Readers' Views and Comments

### Molecular Physics of Ore Flotation

To the Editor of *Chemical & Metallurgical Engineering*

SIR:—I note the communication from G. W. Van Arsdale in your issue of July 15, in which he offers a correction to a statement made by Mr. Anderson and myself in your issue for June 1, 1918.

In the absence of Mr. Anderson who is now in the training camp with the army engineers, I shall undertake a brief reply.

When I read the part of Mr. Van Arsdale's paper to which he refers, my mind reverted to ancient literature—ancient in terms of the age of American literature on flotation. If the reader will refer to the *Mining & Scientific Press*, vol. 3, p. 544 (1915), he will see that I once fell a victim to this same incorrect definition of surface-tension to which Mr. Van Arsdale refers. I soon discovered my mistake and hastened to correct my error, and the correction appears in vol. 112, p. 315. It was indeed a great surprise to me to find one of our leading contributors to the literature on flotation giving credence to this erroneous definition by saying: "As a matter of fact it can easily be shown that a square centimeter of water will support much more than this weight." I understand from this that Mr. Van Arsdale proposes to apply a factor, and further, that he declares that the factor shall be greater than unity. I see no element of scientific fact in this statement, because if, for example, the angle of contact is zero, the degree (factor) of flotability is also zero. For the explanation of this fact I can only refer to the article containing the paragraph with which Mr. Van Arsdale differs.

I regret it if Mr. Anderson and I have said anything that puts Mr. Van Arsdale before the readers as the chief, or only, transgressor of facts. I wish to take this opportunity to state that if a list were to be made of those who have mis-stated principles of flotation, my name should be included. In short, I believe that the only one who has not made mis-statements is the parasite who has stated nothing. There is no place in the study of flotation for the man who does not make mistakes. I once found justification in the literature on colloid chemistry for adhering to a theory, to wit, that all floatable bodies were surrounded by a liquid surface-tension film when submerged. Our study of flotability, a part of the results of which are contained in our article to which Mr. Van Arsdale refers, has convinced me that this theory is untenable.

Seattle Wash

WILL H. COGHILL.

### Flotation Apparatus

To the Editor of *Chemical and Metallurgical Engineering*

SIR:—An error has apparently crept into the minds of various writers to the technical magazines to the effect that the Towne-Flinn flotation patents concern only the cylindrical type of machine used at several demonstrations, and out of which have appeared at various times in the magazines. Also a parallel error arose to the effect that we used only a carborundum

stone as a porous medium, when, in fact, a canvas bottom was among the first used in any of the various types of machines we designed. It would seem only fair to the late Mr. Robt. S. Towne and myself to state the truth at this time.

We were led into the pneumatic process from our observations while trying to develop an acid-proof filter in 1908. At that time, in cleaning our filter medium, which chanced to be carborundum stone, we reversed the air and blew through the stone. While doing this both with canvas and porous stones, we noticed the beautiful bubble screen and the action of the sulphide present with the bubbles formed. At about that time we were also carrying on investigations with the Elmore and Murex processes, and so were quite familiar with oil processes then suggested for use. In our experiments we used the wood distillation products so commonly demanded now in flotation work. However, it was not until a later date that we developed the "bubble column process" or the pneumatic process as now carried on. Among our earliest types of machines were the cylindrical, step, cone and what we called the Type B or flowing-type machine. This last machine was remarkably similar even in small details to the so-called Callow type which was developed by Mr. Callow at a later date. In the early days certain large mining groups in our country became very much interested in our pneumatic process and a mutual understanding arose that we would demonstrate it at one of their plants in counter-distinction to the beating or froth process which was just coming into prominence, and it was with this idea of demonstrating a process and not any special type of machine that Mr. Towne agreed to their request. His idea was to avoid any competitive tests between one machine and any other, but to give a demonstration of the pneumatic process as against the Minerals Separation process. Unfortunately delays crept in from sickness and other reasons, and the greater part of a year passed before we could carry out these plans. Litigation arose; moreover, at this time the Callow machine made its debut at the National Copper Company's mill.

We were convinced that the bubble column process had advantages over the froth process and were granted our claims for a process patent by the Patent Office. Being assured of this and being advised by our lawyers that we were fully protected, we did not push the patents for the various machines as actively as we should have done. This, of course, brought about interferences in the Patent Office with Callow, Cole and others. Mr. Towne's death in 1916 stopped our active work.

While the testimony was being taken in the interference case between Callow and ourselves in 1917, a very satisfactory agreement was arrived at, and we sold our basic patent and machine applications to strong interests. This seemed a wise policy, as otherwise years of litigation might have arisen and further disturbed the mining world. If we had followed out

our first impulse we would have given the public the entire knowledge and result of our experiments in the fall of 1912, and in fact had started to write an article for publication, but came to the conclusion that it would be wiser not to do so. We did and do yet maintain that our basic patent claims will prevent the use of any pneumatic machine without our permission, but of course that can only be decided by the courts.

In making these statements, I do not want to detract from Mr. Callow's glory in pushing his ideas and advancing the art as he has. Because of Mr. Towne's death and the selling out of our patent applications, I withdrew from any active part in the flotation field with regret, as it certainly contains much of interest worthy of scientific investigation.

Our use of the carborundum stone came about from the fact that we felt sure that some way would be found to clean the air blown through the stone, for our observations led us to believe that the blanking of the air passages came from deposits on the lower sides and not on the upper surfaces. Again if the bubbles be examined in a glass tubing it becomes apparent that more bubbles were formed by passing the air through stone than through a canvas bottom. As the efficiency of the process depended on bubbles, it seemed to us at that time that the thing to do was to use the one which formed the most. But by no means were we tied down in our patents to the use of any one kind of porous medium, and felt that the best type of machine and bottom could best be decided on after a long run in the mill. As to the capacity of any machine, it seems to vary with the ore and class of material treated. I must say frankly that I am not one of those who think that the pneumatic process is the only process, for I think that there are ores where the froth process seems to give the best results, and in other cases the pneumatic.

In closing, I will say that we tried passing  $H_2S$  and  $CO_2$  gases as well as air through the bottom.

Newark, N. J.

F. B. FLINN.

## Recovery of Molybdc Acid for Steel Mills

*To the Editor of Chemical & Metallurgical Engineering*

SIR:—The following method for the recovery of molybdc acid from the analytical filtrates of phosphorus determinations has proved very economical as well as highly desirable in maintaining a supply of that reagent.

The method consists of the precipitation of the molybdc acid from the ferric nitrate solution with an excess of phosphate. Five times the theoretical amount of phosphate is added to the boiling solution. The filtrates from 3500 cc. of ammonium molybdc solution are heated to boiling and a solution containing 200 grams of commercial sodium phosphate added. The precipitate is allowed to settle and after the solution is decanted is transferred to a large mouthed bottle. When sufficient yellow precipitate from several precipitations is obtained, it is washed by decantation, transferred to a dish, the water evaporated off and the precipitate dried on a sand bath. According to the commonly accepted formula for the yellow precipitate, it contains 92%  $MoO_3$ ; 210 grams would contain the

same weight of acid as  $\frac{1}{2}$  lb. of 85% molybdc acid. Accordingly for the precipitation of the molybdc acid solution, 210 grams of yellow precipitate are weighed and 800 cc. of water added, followed by 600 cc. of ammonia. The solution is cooled and 35 grams of magnesium nitrate, dissolved in 100 cc. of water are added to precipitate all the phosphorus. After the solution has stood for some time, it is filtered and the precipitate is washed with 100 cc. of water or dilute ammonia. The filtrate is added to 1900 cc. of 1:1 nitric acid, the total volume being 3500 cc. and containing the usual amount of ammonia and nitric acid. W. H. LYNAS.

Columbus, Ohio.

## Research Preparedness in the Zinc Industry

*To the Editor of Chemical & Metallurgical Engineering*

SIR:—I have read the interesting article by Parker C. Choate, under the above heading, in the July issue of your journal. I agree with the majority of his deductions and proposals, while some seem somewhat obscure and require further elucidation, even to one familiar with both the technical and practical side of zinc metallurgy. This is perhaps logical, in view of the radical changes proposed. I would like to know, for instance, how he proposes to extract the lead, silver and other valuable metals from the raw sulphide by leach electrolysis; also further particulars on his "volatile concentration" scheme, etc.

I do not agree with the statement that he sees little value in making sulphuric acid. On the contrary, saving the sulphur by making sulphuric acid enables the modern smelter works to survive hard times and close smelting margins, which will compel many of the antiquated plants to close down sooner or later. When it is considered that for every 100 tons of 60 per cent blende roasted in those plants, approximately 30 tons of sulphur is discharged into the atmosphere and lost, the waste becomes appalling, especially at the present time when every ton of sulphur is needed for the successful prosecution of the war. In pre-war times the sulphur value was rated at about \$1.50 per ton of ore, and at present it is safe to say that it is worth not less than \$5. Indeed, figuring brimstone containing over 99 per cent sulphur at an average value of \$30 per ton, a zinc concentrate containing 30 per cent sulphur ought to be worth \$7.50. Of course, I note Mr. Choate's plan to recover the sulphur from the calcium sulphide formed during distillation, so it would not necessarily be lost.

The writer has had no experience with briquetting the charge, but from a theoretical point of view, it seems a very promising line of investigation.

Mr. Choate's statement that pulverized coal will be found a most efficient auxiliary, is very much to the point. Years ago, while the writer was connected with a zinc smelting concern, he was first to suggest powdered coal for zinc smelting, before its recent general appreciation. The idea was taken up by the management, but the writer was given no opportunity to assist in its development during the later stages, as certain members of the management wanted to take all the credit for their own aggrandizement. This is the sad story of research in some companies at least, with non-technical superiors.

ERIC JOHN ERICSON.

Chicago, Ill.

## Solder Without Tin

To the Editor of Chemical & Metallurgical Engineering  
 SIR:—The following notes on solder may be of interest in view of the scarcity of tin and the necessity of substituting for it wherever possible. The notes are taken from the records of experiments on a somewhat different subject and are consequently incomplete.

### LEAD-CADMIUM

The lead-cadmium alloys possess some desirable properties as solders and furnish the base for addition of other metals, giving solders of different characteristics. The melting points of the lead-cadmium alloys are shown in the diagram, Fig. 1. The final hardening temperature of these is above the melting point of ordinary solder. However, this would constitute an advantage for many purposes.

The following tests show the relative strengths of joints soldered with lead-cadmium alloys and pure tin at various temperatures. The tests were made by pulling apart two copper rods ( $\frac{1}{8}$ -in. diam.) which had been soldered end to end. The strengths of the joints are expressed in pounds necessary to pull apart a union of 1 sq.in. surface. The tests at elevated temperatures were made by immersing the soldered pieces in an oil bath. The 8 to 9 per cent Cd solder seems to be the best, cost as well as strength being considered.

### RELATIVE TENSILE STRENGTHS OF JOINTS SOLDERED WITH LEAD-CADMIUM ALLOYS AND PURE TIN

| Per Cent Cd   | Melting Range, Deg. C. | 20° C. | 110° C. | 150° C. | 290° C.               | 245° C. |
|---------------|------------------------|--------|---------|---------|-----------------------|---------|
| 2             | 290-320                | 8,920  |         |         |                       |         |
| 2.5           | 270-300                | 9,700  |         |         |                       |         |
| 4             | 249-295                | 13,000 |         |         |                       |         |
| 6             | 249-285                | 13,250 |         |         |                       |         |
| 7             | 249-280                | 12,730 |         |         |                       |         |
| 8             | 249-278                | 16,650 | 10,350  | 5,630   | 3,570                 | 2,080   |
| 8.5           | 249-275                | 17,300 |         |         |                       |         |
| 9             | 249-274                | 16,800 |         |         |                       |         |
| 10            | 249-273                | 14,000 | 6,120   | 5,540   | 3,030                 |         |
| 20            | 249-259                | 12,350 |         |         |                       |         |
| 30            | 249-260                | 16,800 |         |         |                       |         |
| 50            | 249-273                | 12,380 |         |         |                       |         |
| 75            | 249-280                | 11,200 |         |         |                       |         |
| Pure tin      | 232                    | 14,100 | 6,450   | 5,350   | 3,770 (1,530 at 230°) |         |
| Pure lead     | 327                    | 7,130  |         |         |                       |         |
| Pure cadmium  | 321                    | 6,620  |         |         |                       |         |
| Half and half | 180                    | 14,800 |         |         |                       |         |

There are several difficulties which are encountered in the use of these solders. They cannot be used with the usual soldering fluxes, although glycerine gives fair results. The best flux which we were able to find is the following mixture of fused chlorides:

|                    | Per Cent |
|--------------------|----------|
| Sodium chloride    | 11       |
| Potassium chloride | 14       |
| Zinc chloride      | 65       |
| Ammonium chloride  | 10       |

This may be used sparingly either melted or in dilute aqueous solution. This flux cannot be used in soldering complicated parts, such as electric motors, where it is impossible to remove all traces of excess flux. Metallic salts cause corrosion of copper on prolonged exposure to the air. With zinc chloride the corrosion takes place in a very short time.

Furthermore, the solder does not flow well on cold copper. It is necessary to heat the copper rather hot, and this often results in oxidation. The cadmium begins to oxidize about 30 deg. above the melting point of the solder. Consequently, it is necessary to maintain a very even temperature if the solder is to be used in a soldering pot. Under ordinary shop conditions, such use would not be practical.

### LEAD-CADMIUM-TIN

Several references have been made recently to solder composed of lead, cadmium and tin. Our experiments with this solder were somewhat limited, but it was our experience that the addition of tin lowered the melting point of the solder as well as the strength of the soldered joint. The solder did not seem easier to flux than the lead-cadmium solders unless a large amount of tin

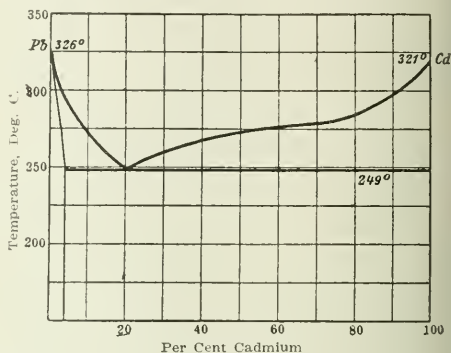


FIG. 1.—MELTING POINTS OF LEAD-CADMIUM ALLOYS

were added. Metallic chloride fluxes seemed to be required in most cases where these solders were tried.

### LEAD-CADMIUM-ZINC

Lead-cadmium alloys do not seem to dissolve zinc in quantities much above 1.5 to 2 per cent. Upon slow cooling excess zinc rises to the top bearing with it lead and cadmium. By stirring well before pouring, solders have been made with excess of zinc over that required for solution and the solders appeared to give good results. Tests of strength of soldered joints between copper rods showed values equal to those obtained by tin, half and half, or lead-cadmium solders at room temperatures. No tests were run at elevated temperatures. The fused chloride flux above mentioned may be used with these solders; but very good results were obtained by using a mixture of rosin, ammonium chloride and alcohol. The best solders appear to be those with a relatively small amount of zinc, especially where the soldered joint cools slowly or where the layer of solder is thick. A slight excess of zinc did not appear to lower the strength of the solder, those composed of 5 per cent zinc added to the 8.5 per cent Cd-92.5 per cent Pb above mentioned, giving excellent tests. Such a solder may be used with an iron where the work is not heavy. It solders well on tin, zinc, copper and iron. Clean tin sheet can be soldered without the use of a flux. The melting range is about 250-280 deg. C., depending upon composition.

There seemed to be but little trouble from oxidation even when the solder was overheated. Such solders would seem, on the basis of our limited experience, to be applicable to a wide variety of work.

Many of the data given above were obtained by Mr. Geo. P. Luckey, who has since entered the service.

CHARLES W. HILL.

Westinghouse E. & M. Co.,  
 East Pittsburgh, Pa.



## War Industries Board Discourages Further Expansion of Electric Steel

**M**ANUFACTURERS of electric furnaces in the United States have recently been confronted with the possibility of curtailing their business on account of the reported attitude of the War Industries Board against further expansion in the electric steel industry. When the matter was brought to the attention of CHEMICAL AND METALLURGICAL ENGINEERING we took the matter up through our Washington office and were informed that the Board was granting no new permits for electric steel plants in the restricted power districts of New England, and that the controlling factor was an ample supply of electric steel. On inquiry among electric furnace manufacturers we discovered that various reasons had been assigned to them, among others being the shortage of electrodes, shortage of power and a supply of electric steel in excess of demand. It was also ascertained that individual furnace manufacturers were acting on their own initiative in protest against the action of the Board, feeling that too drastic action might be taken that would vitally effect the furnace business. We have since suggested to all makers of electric furnaces in the country that they unite in the presentation of their side of the case to the War Industries Board, so that nothing will be done without thorough understanding of conditions, both by the Board and the manufacturers.

In the meantime the case for electric steel and the electric furnace has been brought to the attention of the Board through communications which we reproduce herewith in part.

Mr. C. H. BOOTH, of the Booth-Hall Co. has addressed the Board as follows:

We wish to vigorously protest against this action on your part. As a member of the American Iron and Steel Institute, the writer was present at the spring meeting in New York City, and heard Mr. J. L. Replogle make a public statement that the steel demands for building of ships and the requirements of the Army and Navy were so great that it was very doubtful whether the entire steel production of the United States would be adequate to take care of the demand as fast as would be required. We cannot understand why conditions should have changed within the last sixty days to such an extent that you are warranted in discouraging the building of new steel capacity. The more electric furnaces that are placed in operation producing steel either in the form of high-grade alloy and tool-steels or high-grade steel castings, the more will the open-hearth and bessemer capacity be available for the manufacture of plates, structural steel and the other more common grades which are so much needed. In the steel casting field there will be released similar capacity for the manufacture of heavy castings where weight is the chief essential, or for the manufacture of ingots to be rolled into finished steel.

### GOVERNMENT SHOULD AID ELECTRODE MANUFACTURE

Mr. DuBois has suggested that there is liable to be a shortage of electrodes, and for that reason the installation of new electric furnace capacity should be held back. On the other hand, we wish to point out that if the use of electric furnaces is encouraged, and not discouraged, it will stimulate the electrode industry. Why not aid the present manufacturers of electrodes to increase their capacity, or encourage the formation of new companies? With government aid, many problems much more complicated and technical than the manufacture of electrodes have been mastered and large outputs obtained. The manufacture of electrodes is quite simple by contrast and should be quickly and easily handled.

The merits of the electric furnace in conservation of materials were set forth by Mr. BOOTH as follows:

*Conserving Manganese.* The atmosphere in an electric furnace is either neutral or reducing. In either case there is no air draft to burn out the manganese contained in the steel or to oxidize the steel. Consequently less manganese need be added to make up losses and to deoxidize the steel. As contrasted with the electric furnace, the open hearth requires 50 to 100 per cent more and the steel converter 100 to 200 per cent more manganese. The electric furnace requires approximately 10 pounds of ferromanganese per ton of mild steel, so that the saving will be from 5 to 10 tons of ferromanganese to each 1000 tons of steel.

It is the usual practice in steel plants to add ferromanganese and spiegeleisen to steel, either in cold or pre-heated form. By melting the manganese in an electric furnace and adding it to the steel in molten form, the quantity of manganese needed to deoxidize the steel is greatly reduced. An article in the December 15, 1917, issue of METALLURGICAL AND CHEMICAL ENGINEERING, on pages 702-704, gives figures showing an actual saving of 44.3 per cent by adding molten ferromanganese as against adding pre-heated ferromanganese. The figures in question showed a consumption of 22.5 pounds of pre-heated ferromanganese per long ton of steel against 9.9 pounds of molten ferromanganese. This represents a saving of more than 560 long tons of ferromanganese per 100,000 tons of steel. Compared with adding ferromanganese cold the saving will be even larger.

The general use of the electric furnace for melting manganese additions to bessemer and open-hearth steel would result in reducing the requirements for manganese by nearly half.

*Conserving Pig Iron.* Both the open-hearth and converter processes when used for melting cold stock demand the use of pig iron and steel scrap. The proportion of pig iron to steel scrap depends upon the individual plant practice, but it may be said that approximately 40 to 60 per cent pig iron is used in converter practice and 25 to 40 per cent pig iron in open-hearth practice. The electric furnace processes alone allow the use of 100 per cent steel scrap without any pig iron being needed. The use of the electric furnace in place of the open-hearth and converter for melting cold stock wherever practical would result in a conservation of pig iron, releasing a large tonnage of pig iron for other purposes.

*Conserving Plumbago.* Plumbago is used extensively in the manufacture of crucibles. Crucibles are used extensively for the melting of brass and the production of tool-steels. The electric furnace is being used widely for the production of tool-steels, and there are still many plants using the crucible process which could change over to the electric process with profit. The use of the electric furnace for brass melting is still in its infancy and offers possibilities that may one day rival the use of the electric steel process. The use of the electric furnace in place of crucibles for brass and tool-steels would result in releasing a large quantity of plumbago for other necessary purposes.

*Conserving Coke.* The converter process of melting cold stock requires the use of a ton of coke to every 3 or 4 tons of steel. The electric process requires the use of no coke whatever. The use of the electric furnace in place of the converter for melting cold stock would release many thousands of tons of coke for other purposes yearly.

*Conserving Steel and Iron.* In every melting process there are losses of materials. Melting cold stock the loss will be from 7 to 11 per cent in large open-hearths, from 10 to as high as 25 per cent in small open-hearths and from 18 to 25 per cent in steel converters. In the electric furnace, the melting loss has been demonstrated to be approximately 4 per cent, this low figure being due to the absence of any oxidizing draft in the electric process. The use of the electric furnace in place of open-hearth or converter for melting cold stock would result in a saving of from 3 to 21 tons of steel for every 100 tons produced. This represents a conservation of natural resources.

The essentials to the operation of electric furnaces are electric power and electrodes. Of electric power, both steam and water generated, there is excess available throughout the country, particularly in the South, Middle West, Northwest, and West. Of electrodes there tends to be a shortage due to the expansion of

electrode manufacture not keeping step with the rapid expansion of the electric furnace industry. This is the only condition that must be taken care of in order to permit of installing additional electric furnaces and effecting the conservation of necessary materials as listed above. It is a condition easily remedied as the production of electrodes requires comparatively small investment and is a fairly simple process that has been thoroughly worked out in existing plants.

It is our contention:

First:—That the Government through the War Industries Board should encourage and aid the expansion of the electrode making industry, using methods similar to those used in increasing the output of other necessary materials.

Second:—That the Government should not restrict the installation of electric furnaces to the limited supply of electrodes, but should encourage the production of electrodes on a scale to keep pace with the growth of the electric furnace industry.

Third:—That the Government should encourage in every way the replacement of converters by electric furnaces for melting cold stock so that the considerable saving in pig iron, coke, manganese, and steel may be secured.

Fourth:—That the Government should encourage wherever practical the installation of electric furnaces for the melting of manganese additions to Bessemer and open-hearth metal.

Fifth:—That the Government should encourage the replacement of small open-hearth furnaces for melting cold stock and of crucible furnaces for brass and tool steel by electric furnaces.

Mr. VOMBAUR, of the T. W. Price Engineering Co., approached the matter from a different angle, and showed the advantages of the electric furnace in reducing the expense of transportation of materials and the release of rolling stock for other purposes.

We have a case in mind where 5300 hydro-electric horsepower is available on the Pacific Coast, where a large forge shop is now purchasing open-hearth ingots from the East. These are usually made from direct-metal refined in the open-hearth. The great saving in freight by making electric steel on the Pacific Coast rather than buying ingots in the East is indicated in the appended table, calculated on a 1000-ton basis.

|                                                                                               | Tons      |
|-----------------------------------------------------------------------------------------------|-----------|
| Iron ore, 50% Fe .....                                                                        | 2,000     |
| 20% crop of open-hearth ingots.....                                                           | 200       |
| Coke, 114% x 2200 tons (Forsythe).....                                                        | 2,508     |
| Coal, at least 133% of coke.....                                                              | 3,344     |
| Limestone, 112% x 2200 tons (Forsythe).....                                                   | 2,464     |
|                                                                                               | 10,516    |
| Ingots themselves .....                                                                       | 1,000     |
|                                                                                               | 11,516    |
| Less scrap hauled for electric furnace plant from Pacific Coast ports, plus 10% for crop..... | 1,100     |
| Saving in tonnage .....                                                                       | 10,416    |
| Mileage for railway haul.....                                                                 | 400       |
| Ton-miles .....                                                                               | 4,166,400 |
| Cost at one cent per ton-mile.....                                                            | \$41,664  |

This case is typical of many others, and since the electric furnace in making steel of whatever nature usually uses over 95 per cent scrap, and in some cases all scrap, it is evident that it is one of the greatest economic factors in the iron and steel industry to-day. The situation represented in the tabulation does not consider the fact that from 17 to 19 pounds of either 70 or 80 per cent ferromanganese or an equal amount of ferrosilicon is required by the open-hearth furnace per ton of steel, while the electric furnace requires but half as much. Also the supplies required to keep an electric furnace going are much less than those required to continue an open-hearth or Bessemer in operation. Again, the higher ignition loss in the open-hearth furnace as compared with the electric furnace does not appear in the computation.

## Government Needs Thousands of Draftsmen for War Work

THE vast activities of the Government in construction and manufacture in connection with the war program necessitate the employment of literally thousands of additional draftsmen of various kinds. The United States Civil Service Commission, whose duty it is to recruit these civilian positions, announces vacancies in large numbers of drafting positions. The filling of these positions is urgently necessary, as they have a direct connection with the war organization. Applicants will not be required to report at any place for examination, the ratings being based upon the applicant's education, training, experience, etc., as shown by the application and corroborative evidence. Full information and application blanks may be obtained by communicating with the United States Civil Service Commission, Washington, D. C., or with the secretary of the board of civil service examiners at Boston, New York, Philadelphia, Atlanta, Cincinnati, Chicago, St. Paul, St. Louis, New Orleans, Seattle, or San Francisco.

Following is a list of the drafting positions now open in the civil service, and the entrance salaries paid:

### WAR DEPARTMENT

#### Construction Division

| Title                                  | Sex | Usual Entrance Salary |
|----------------------------------------|-----|-----------------------|
| Architect .....                        | M   | \$2500-\$3500 a year  |
| Structural designer .....              | M   | 2400-2700 "           |
| Architectural designer .....           | M   | 2100-2700 "           |
| Senior architectural draftsman .....   | M   | 1800-2100 "           |
| Junior architectural draftsman .....   | M   | 1200-1800 "           |
| Architectural tracer .....             | M   | 1000-1200 "           |
| Quartermaster Corps and Ordnance Dept. |     |                       |
| Automotive engineer .....              | M   | 2400-7200 "           |
| Automotive engineer .....              | M   | 1800-3000 "           |
| Automotive draftsman .....             | M   | 1400-2000 "           |
| Automotive tracer .....                | M   | 1000-1400 "           |

#### Signal Service

|                                         |     |             |
|-----------------------------------------|-----|-------------|
| Aeronautical mechanical draftsman ..... | M   | 1200-1400 " |
| Ordnance Dept.                          |     |             |
| Mechanical draftsman .....              | M&F | 800-1800 "  |
| Gauge designer .....                    | M   | 2000-3000 " |
| Automobile draftsman .....              | M   | 800-1800 "  |
| Apprentice draftsman .....              | M   | 480 "       |

### NAVY DEPARTMENT

|                                                                               |     |                     |
|-------------------------------------------------------------------------------|-----|---------------------|
| Ship draftsman .....                                                          | M&F | \$4.00-\$6.88 a day |
| Architectural, mechanical and structural-steel draftsman (for ship work)..... | M&F | 4.00-6.88 "         |
| Topographic and subsurface draftsman .....                                    | M   | 1.48-5.04 "         |
| Radio draftsman .....                                                         | M&F | 3.52-6.00 "         |
| Copyist draftsman .....                                                       | M&F | 2.00-3.44 "         |
| Bureau of Yards and Docks                                                     |     |                     |
| Mechanical draftsman, armor and steel plant.....                              | M   | 4.00-8.00 "         |
| Engineering draftsman .....                                                   | M&F | 3.04-7.04 "         |
| Bureau of Ordnance                                                            |     |                     |
| Mechanical draftsman .....                                                    | M&F | 4.00-7.84 "         |
| Bureau of Construction and Repair                                             |     |                     |
| Metal furniture draftsman.....                                                | M   | 4.00-6.00 "         |
| Aeronautic draftsman .....                                                    | M   | 4.00-5.04 "         |
| Bureau of Steam Engineering                                                   |     |                     |
| Electrical draftsman .....                                                    | M&F | 4.00-6.40 "         |
| Marine engine and boiler draftsman .....                                      | M&F | 3.28-7.04 "         |

### INTERIOR DEPARTMENT

#### Geological Survey

|                                     |     |                      |
|-------------------------------------|-----|----------------------|
| Copyist topographic draftsman ..... | M&F | \$1100-\$2000 a year |
|-------------------------------------|-----|----------------------|

### DEPARTMENT OF COMMERCE

|                                              |   |                    |
|----------------------------------------------|---|--------------------|
| Hydrographic and topographic draftsman ..... | M | \$1000-1200 a year |
| Apprentice draftsman .....                   | M | \$60 a month       |



## Chemical Exposition to Demonstrate American Independence

THE Fourth National Exposition of Chemical Industries, to be held in Grand Central Palace, New York, September 23 to 28, will demonstrate through the multitude of new products exhibited that the American chemist has answered fully the call made upon him since the present war began. It will prove conclusively that the chemists had the ability and the knowledge to develop the facilities for making practically all of the products heretofore believed impossible to be made here. Like our fighting forces they have accomplished in a few years what it required Germany nearly fifty years to do.

The exhibits will cover a wide range from the raw materials of the ground to the highest processes for refining and producing the finished product. The exposition will cover all the ramifications of the chemical and allied industries and men in every branch of industry will find therein the materials and machinery that they can apply in their operations. It will be an exposition for the utmost in efficiency, progress and inspiration.

Coincident with the exposition will be held a number of important conferences which will bring thousands of chemists to New York from all parts of the country. The theoretical and practical phases of chemistry will be not only discussed thoroughly but illustrated as well. Men prominent in various branches of industry, bankers and government officials will be on the daily programs along with the leaders in the chemical world. The exposition will bring together manufacturers of machinery, equipment, supplies etc., and with them will come men who will explain their operation. Many intricate machines built since the United States entered the war will be exhibited and these will prove interesting and instructive. Generally speaking, the exposition will be a big school of learning and any one who misses it will have cause for regret. The papers to be read will give some idea of the remarkable things being done by American chemists in the war and industry and these will also be of interest to the general public. Pressing chemical problems concerning many of the chief articles of domestic and foreign commerce will be taken up during the conferences and it is expected that these discussions will have an important bearing on the manufacture of articles that have been scarce and high-priced ever since the curtailment of American commerce with Germany and other countries.

The exposition is a war-time necessity, and regarding it as such each exhibitor is planning his exhibit so that it will be of greatest benefit to the country through the men who visit it, all of whom are bent upon a serious purpose—that of producing war materials in large quantities, and constantly increasing this production till the war has been won by the United States and her allies.

Manufacturers, large and small, are showing unusual interest in the exposition and applications for space have been so numerous that Charles F. Roth and F. W. Payne, the managers, have made special provisions for housing the displays. The various floors which will be utilized to display the products of the industry will be filled to overflowing with everything that is new and interesting in the chemical field.

The program for the exposition is now being prepared. There will be a series of symposia on the "Development of Chemical Industries in the United States, notably since July, 1914." This will embrace the period since the beginning of the European war, which by removing the source of supply for our domestic industries, inspired the development of our own chemical industries that are so efficient in the war. There will be pictures of many chemical, mining and related industries. In fact every field of endeavor from the products within, upon and above the earth with which chemistry deals, will be shown. There will be a series of films depicting carelessness, the destruction of life, wealth and resources, that show hazards and risks in industrial plants and how they may be overcome. The dangers of fire and explosives will be demonstrated and the prevention of disease by vaccines illustrated.

The complete program of speakers and motion picture program will be announced in our Sept. 1 issue.

Some sections of the South again are sending exhibits. Canada is taking the opportunity of presenting the materials it has available for development by the chemist and financier. Technical and business men all over the country should give heed to these exhibits since they will show how they can meet the war time need. A section for the glass and ceramic industry has been added with which the American Ceramic Society is co-operating.

The advisory committee is composed of Charles H. Herty, chairman, Raymond F. Bacon, L. H. Baekeland, Ellwood Hendrick, Henry B. Faber, Bernard C. Hesse, A. D. Little, Wm. H. Nichols, R. P. Perry, H. C. Parmelee, G. W. Thompson, F. J. Tone, T. B. Wagner and M. C. Whitaker. Charles F. Roth and F. W. Payne are the managers.

## The Sulphur Monopoly and Sulphuric Acid in Georgia

The Geologic Survey of Georgia has issued a bulletin of 229 pages, descriptive of the pyrite deposits of that state. Georgia has more sulphuric acid plants than any other state and has used small quantities of local pyrite for many years, ninety thousand tons being mined annually. This is highly important in regard to the fact that two companies—the Freeport Sulphur Co. and the Union Sulphur Co.—produce all the sulphur in this country, price data on which is given in the *Official Bulletin* of June 29, 1918, as follows:

The cost of the Freeport Co. in 1917 was \$6.15 per ton; in 1918 it is estimated that increases will bring the cost up to not over \$9.50 per ton. In the first half of 1917 the Union Co.'s costs were \$5.73 per ton. The average realization of the Union Co. in the first half of 1917 was \$18.11 per ton, making a margin of \$12.38 per ton. The manufacturers of sulphuric acid are paying in the neighborhood of \$25 per ton, and some as high as \$35 per ton, making margins of over \$15 per ton for sulphur companies. The Freeport Co.'s balance sheets show an operating profit for the eleven months ending October 31, 1917, of \$4,301,310, or 236 per cent on investment. On November 30, 1916, the company's balance sheet shows dividends declared of \$925,000; on July 31, 1917, \$1,850,000; and October 31, 1917, \$2,600,000. Its surplus increased from \$1,254,000 in November, 1916, to \$2,543,000 in October, 1917.

These two companies have been to considerable patent litigation expense. Recently the Government took over the control of their operations so as to prevent a shortage of sulphur.



## War Department Centralizes Purchasing Control

ORGANIZATION of the centralized purchasing scheme whereby the General Staff controls the buying of all commodities and supervises all contracts for the Army is rapidly progressing. Already assignment of purchases of a number of commodities has been made to the several branches of the War Department, and boards of review are passing on all contracts in order to insure uniformity of contract control and provisions. The general administration of the scheme is under the direction of Brig. Gen. Hugh S. Johnson, head of the purchase and supply branch of the division of purchase, storage and traffic of the General Staff of the Army.

In the past the various branches of the department have been buying their respective commodities through their own purchasing agencies, often bidding against one another for the same goods and frequently paying several different prices for the same article. The General Staff brought together a committee of representatives of the various purchasing agencies, and this committee is now engaged in standardizing the commodities needed and assigning to one branch of the department the purchase of each commodity. This standardization has progressed to the point indicated in the accompanying list, which shows the name of the branch intrusted with the purchase of about 150 items so far agreed upon. Others are being added to the list each day:

Quartermaster: Automobile drive, chain, iceboxes, bur-lap, non-skid chains, cotton cloth, cotton goods, cotton rope, silk fabric, rubber goods, woolen rubber goods, jutes, leather, linen, manila rope, needles, woolen goods.

Construction: Reinforcing bars, cement, clay products, electrical equipment and supplies, electric wire for heavy power, refrigerating equipment, sand and gravel, rough hardware, heaters, room heating equipment and supplies, plumbing equipment and supplies roofing material sprinkler systems, ventilating equipment, water supply equipment and fixtures, structural steel.

Ordnance: Chrome and ferro-manganese alloys, ammonium nitrate, artillery chain, barometers, dry batteries, blast furnace and steel mill products, cartridge cloth, coal gas products, coal tar products, cotton lint, forging equipment, hull fiber, flash lights, dry cell lanterns, nitrates, tin, pig tin, plate tin, platinum, sodium nitrate, stop watches.

Engineers: Arc search lights, chain, paint containers, gantry cranes, locomotive cranes, paint driers, electric gas generator sets, enamels, gas engines, mechanical rubber goods, japans, lacquers, mineral spirits, paint, steam shovels, turpentine, varnishes, linseed oil, railway equipment.

Signal: Electric wire, radio equipment, telephone and telegraph equipment.

Aircraft production: Aeroplanes, cable, clocks, aviators' clothing, compasses, wood distillates, gages, oil, air and gasoline, steel hangars, linen fabric for balloons and aircraft, thermometers, spar varnish.

Medical: Surgical dressings, surgical needles, medical thermometers.

Chemical and War Gas. Elastic tape, horse masks.

Thus, ferro-alloys or ammonium nitrate, regardless of their use or of the branch that uses them, are purchased by the Ordnance Division according to specifications laid down by that division. Any other branch requiring these articles makes a requisition on the Ordnance Division for the required amount. More than 70 per cent of the articles bought by the department are now being purchased under this system.

It has been decided by the Superior Board of Review of the General Staff that, wherever possible, fixed price

contracts shall be used in the purchase of supplies for the War Department. In the exceptional cases, where it is clearly to the advantage of the Government that a cost plus contract be used, a cost plus fixed compensation contract is to be made, rather than a cost plus percentage contract.

## Federal Regulation of Common and Skilled Labor

ON AUGUST 1 the supplying of war industries with common labor was centralized in the U. S. Employment Service of the Department of Labor, and all independent recruiting of common labor by manufacturers having a payroll of more than 100 men was diverted to the U. S. Employment Service.

While the restrictions against the private employment of labor apply only to common labor at the present time, these restrictions will, as soon as possible, be extended to include skilled labor. In the meantime, recruiting of skilled labor for war production will be subject to federal regulations now being prepared. This drastic change in the nation's labor program has been found necessary in order to protect the employer and the employed, to conserve the labor supply of the communities and to cut down unnecessary and expensive labor turn-over (which, in some cases, is as high as 100 per cent a week), and to increase the production of essentials.

Under the operating methods adopted, the country has been divided into thirteen federal districts, each district in charge of a superintendent of the U. S. Employment Service. The States within each district are in turn in charge of a State Director, who has full control of the service within his State. In each community there is being formed a local community labor board, consisting of a representative of the U. S. Employment Service, a representative of employers and a representative of the employed. This board will have jurisdiction over recruiting and distributing labor in its locality.

When the survey of labor requirements has been made and the aggregate demand for unskilled labor in war work is found, each State will be assigned a quota, representing the common labor to be drawn from among men engaged in non-essential industries in that State. These State quotas will in turn be distributed among localities. Within each locality, employers in non-war work, including those who are only partially in war work, will be asked to distribute the local quotas from time to time amongst themselves. Quotas by localities and individuals are to be accepted as readily as they are for Liberty Loan and Red Cross campaigns. This plan of labor quotas is a protection for all communities. The object is to keep any community from being drained of labor, and to use local supply, as far as possible, for local demand. The situation, however, is such that in certain cases some men may have to be transported over long distances.

The War Department has finally selected the so-called Broadwell site for the half unit of the ammonium nitrate plant to be constructed by the Air Nitrates Corporation at Cincinnati, Ohio. The cyanamid process will be used as in Plant No. 2 at Muscle Shoals, Ala.

# Consumption and Conservation of Tin

THE tin consumption in the United States has increased steadily during the past decade and has been confined only by the limitations of ore supplies, a liberal sufficiency of which has never been located in the surface mineral formations of the earth. Except for the 140 tons of tin obtained near Nome, Alaska, practically the only source of tin ore supply on the American hemisphere comes from Bolivia. About 7500 tons of tin is being produced annually at the plant of the American Smelting and Refining Co. at Perth Amboy, N. J., from Bolivian concentrates, which amounts to about ten per cent of our present consumption.

The tin and terne plate industry and the solder and bearing-metal consumption, each take about one-third of our available tin. According to a statement compiled by the War Industries Board from returns obtained through the sub-committee on pig tin, the consumption of pig tin for different purposes in 1917 was as follows in gross tons:

## TIN CONSUMPTION IN THE UNITED STATES IN 1917

|                              |        |
|------------------------------|--------|
| Tin and Terne Plate.....     | 27,600 |
| Solder .....                 | 17,000 |
| Babbitt, Bearing Metals..... | 10,800 |
| Bronze and Sn-Brass.....     | 4,500  |
| Tin Foil.....                | 4,000  |
| Collapsible Tubes.....       | 2,100  |
| White Metal.....             | 1,764  |

## APPROXIMATE ESTIMATES

|                         |       |
|-------------------------|-------|
| Chemical .....          | 2,570 |
| Britannia Ware.....     | 1,500 |
| Pipes and Fixtures..... | 1,350 |
| Hardware, Utensils..... | 900   |
| Rubber Filler.....      | 190   |
| Galvanizing Alloy.....  | 150   |
| Bullets.....            | 100   |
| Type Metal.....         | 51    |
| Bells .....             | 22    |
| Not Known.....          | 1,350 |

Total..... 76,257

## THE USE OF SUBSTITUTIONS

Asphalt and tar roofing have strongly relieved the demand for terne plate; paraffined or parchmentised paper cartons and glass and pottery jars have come into almost as extensive use as the tin can in food conservation; and the tin alloys, such as solder, babbitt and bronze are being thoroughly studied to bring about a satisfactory product, with a minimum tin content. In regard to these alloys, the Tin Section of the War Industries Board reports:

On account of the limited supply of tin available in the world to-day and because of the hazard involved in connection with our oversea imports upon which we depend for our requirements, and furthermore, because our war program calls for a very large tonnage of tin, it is imperative that we take immediate steps to husband our resources: First, by eliminating all waste; second, by substituting other metals wherever practicable; third, by reducing the percentage of tin used in various alloys just as far as possible, and finally, by recovering larger quantities.

The War Industries Board has conferred recently with representative manufacturers of babbitt and other bearing metals, solder and miscellaneous tin-alloy products for the purpose of explaining the present situation, and in order to obtain suggestions as to the most practicable methods for conserving tin. In co-operation with the Bureau of Standards, a number of experiments have been conducted.

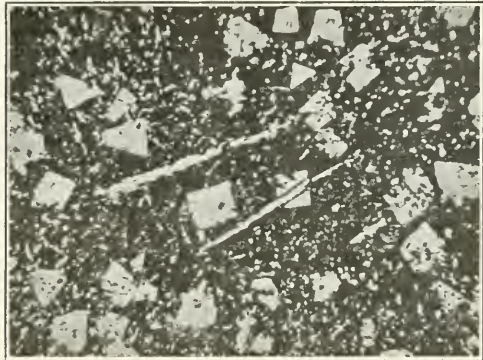
The accompanying statement reports some of the findings of the Bureau of Standards resulting from their experiments and from inquiries made among a number of large manufacturers and consumers. We realize that these suggestions cover only a few means

of reducing our consumption of tin. The War Industries Board will gladly welcome others, particularly as it is expected that each recipient will be influenced in his approach to the problem by consideration of the special needs of his own line of products and manufacturing equipment. It is hoped that the very widest possible use will be permitted of any original findings that may result from a careful study of the problem.

## TIN-BASE BEARING METALS

Tin-base bearing metals are known in the trade as Babbitt Metals and are divided into three classes: 1. Tin, antimony and copper alloys. 2. Tin, antimony, copper and lead alloys. 3. Tin, copper and zinc alloys. In general they are less easily compressed than the lead-base metals. This resistance to compression is due to the relative content of antimony and copper of the bearing alloy, which are not only the hardening and wear-giving constituents but also form a crystal structured skeleton which is covered over by the soft, tough, tin bonding crystals.

Fig. 1 illustrates babbitt metal magnified to fifty diameters. The light crystal cubes are the hard grains of tin-antimony, while the needle-like grains are the



TIN-COPPER-ANTIMONY BEARING METAL

particles of antimony-copper alloy. The dark parts are the depressions in the surface due to the removal of the tin by the etching acid.

In the days of Isaac Babbitt the best known soft metal alloy was a high-grade pewter of the following composition: Copper 3.70 per cent, antimony 7.40 per cent and tin 88.90 per cent; and it was with this pewter that he initiated "babbitting" with the result that the name "Genuine Babbitt" became famous in engineering parlance. In modern practice the copper and antimony content have been increased to as high as 20 per cent, with 80 per cent tin for very hard babbitts. Many specifications now in existence call for virgin tin (Banca or Straits), where, as a matter of fact, just as good binding qualities would be obtained from a second quality pig tin with minor lead, etc., impurities. Lead has the property of lowering the melting point forming an eutectic at 36 per cent tin, but the tin should preferably be over 50 per cent, antimony not less than 12 per cent and the copper not less than 3 per cent.

Parson's white brass, which consists of 62 per cent tin, 35 per cent zinc and 3 per cent copper, is largely used for marine and automobile bearings. Its disad-

<sup>1</sup>"Chemistry of Materials," Leighton, page 187.

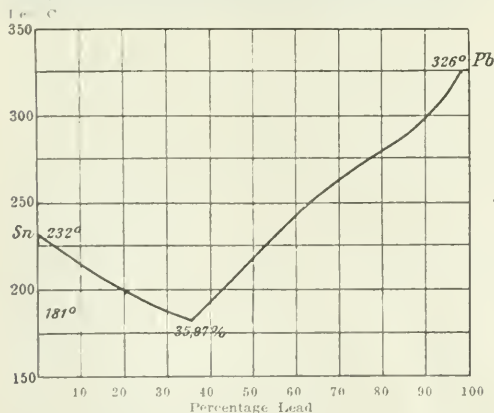
vantages lie in the fact that it has to be poured at red hot temperatures, is very sluggish due to the oxidized zinc skin, and has to be cast heavy, not filling into thin sections well. Perhaps the greatest and best means of conserving tin in the bearing metal industries will be to minimize the thickness and size of babbitts instead of trying to substitute extensively the tin content of the best bearing alloys with lead or zinc. At present, the designing practice is governed almost entirely by the margin of heat needed to counteract the chill during the pouring operation so that a secure bond will be obtained as well as a solid unified mass. The bearing seats are best attached by previously tinning in the presence of a soldering flux ( $\text{NH}_4\text{Cl-ZnCl}_2\text{-HCl-water}$ ) with powdered tin<sup>2</sup>. If the chill of the iron parts has been removed by moderate use of a blow lamp, very great extremes may be reached in the reduction of the thickness of the babbitts.

### SOLDERS

Over one-fifth of our tin is used in the manufacture of solders, ranging from 90 to 36 per cent tin. While the greatest care has not been used in minimizing the tin content of the alloy, most important developments have been made in preventing waste in application through the use of excessive amounts by means of electrically heated soldering irons, automatic solder-wire feeders, etc. Other metals such as cadmium have been tried as substitutes but are not of practical economic use. Perhaps electric welding and spinning operations will eventually be used more extensively, especially as tin actually becomes very scarce and costly. Fig. 2 gives the melting point curve of lead and tin<sup>3</sup>.

### DETINNING SCRAP—THE TIN CYCLE

Very many processes have been proposed for the recovery of tin from waste tin plate scrap and cans gathered by the municipal garbage systems. Ordinarily, all this class of metal is fused in a furnace



MELTING POINTS OF SOLDERS

for such castings as window weights and manufactured iron products which the brittling action of the tin does not greatly affect. Many processes for recovering the tin and solder have been tried out and some

of them were profitable at a time when tin sold for as low as 37 cents per pound. These processes<sup>4</sup> may be divided into three groups: Mechanical, chemical and electrochemical. Most interesting of these is the catalytic action of the allotropic powder form of tin, gray tin, which forms spontaneously at low temperatures and acts catalytically as a detinner at temperatures below 20°C.

The only processes in commercial operation are the low pressure dry chlorine and the sodium stannate methods. The Goldschmidt Detinning Co. recovers over two thousand tons of tin per annum by these processes, on which they hold patents. Because iron is more electro-positive than tin, methods depending on acid solvents are failures. Copper sulphate, stannic chloride, etc., will dissolve tin, but as soon as iron is exposed, the desired reaction discontinues in favor of the solution of the iron. The chlorine process fails when water is not eliminated for the same reason—HCl being formed and the iron becoming the active material. Ammonium and sodium salts of tin give a cation not active to iron and prove practical for wet processes. The handling operations are of extraordinary difficulty, and this alone probably accounts for the limited success of detinning adventures and the extensive creation of the tin cycle.

### Assets of Four Corporations for Sale

A. Mitchell Palmer, custodian of enemy alien property, has directed that the following property be placed on sale:

Berger & Wirth Company of Brooklyn, N. Y. This company was organized about 1909 under the laws of New York for the manufacture of printers' and lithographers' inks. The head office of the company is at 5860 Columbia Heights, Brooklyn. The concern was owned by Emil Worlitzer, whose residence is in Leipsic, Germany. Berger & Wirth own many valuable processes, formulas and equipment for making inks.

G. Siegle Company of Rosebank, Staten Island, New York. This company is a large importer, manufacturer and seller of colors and other chemicals. It was organized under the laws of New York, April 4, 1904. The authorized capital stock of the company is \$250,000, all owned by the G. Siegle Company, a German corporation located at Stuttgart. The plant of the company is located at Chestnut Avenue, Rosebank.

A. W. Faber, Newark, N. J. This company is the American branch of the A. W. Faber Co. of Stein, Bavaria, where it started its crayon business in 1761. It was owned by Alexander Count Faber-Castell and his wife, Otilie Countess of Faber-Castell of Stein, Bavaria. Since 1900 the offices and factory of the American branch have been at Dickerson and Hecker Streets, Newark, N. Y. The manufacture here has been limited to rubber erasers and bands. Henry Fera, Jr., has been general manager of the firm and attorney for the owners.

George Beuda Co., Boonton, N. J. This company manufactures bronze powders and is a branch of the same company at Fuerth, Bavaria, which was established in 1824. From 1905 to 1915, the company imported semifinished material direct from their German works. When the European war cut off all importation, the manufacture was continued from scrap brass.

<sup>2</sup>See *Epicassit, Met. & Chem.*, Vol. XVI, No. 7, Apr. 1, 1917, page 403.

<sup>3</sup>P. N. Degens, *Zeitschrift Anorganische Chemie*, 63, 212, 1909.

<sup>4</sup>*Met. & Chem.*, Vol. XVII, No. 4, Aug. 15, 1917.



## Cleveland Meeting, American Chemical Society

Secretary Parsons announces that the fifty-sixth general meeting of the American Chemical Society will be held at Cleveland, Ohio, September 10 to 13, 1918. A council meeting will be held on the afternoon of September 9, and the council will be entertained at dinner at the University Club by the Cleveland Section. On Tuesday there will be a general meeting at the Hotel Statler, which is to be headquarters. A dinner will be given in the evening at the Statler Hotel, followed, after a convenient interval, by a smoker at the same place. Divisional meetings will be held on Wednesday morning and all day Thursday. On Wednesday afternoon trips will be taken, probably as follows:

A—Sanitary trip. Sewage disposal experiments. Water filtration. Garbage disposal.

B—Steel industries. Blast furnaces, by-product coke, steel, Bessemer, and open hearth.

C—Industrial tour of Cleveland, including all the manufacturing centers, but only a few stops.

D—Trip by special cars to Oberlin.

In the evening the President's address will be given and this will be followed by a reception at the Hotel Statler.

After the divisional meetings on Thursday, automobile trips will be taken to one of the country clubs for dinner and to the Cleveland Museum of Arts. On Friday a special excursion is planned for Akron, Ohio, where there are interesting rubber, pottery, soda, match, and other factories. Luncheon will be served in Akron and the party can leave for home from that city.

The Cleveland chemists are arranging special entertainment, not only for the men but for the ladies who may be present, and every effort is being put forth to make the meeting a success.

Special symposia are being arranged by the chairman and secretaries of divisions and it is believed that an unusual opportunity will be given in these active chemical times for chemists to get together and exchange views and ideas, many of which cannot at present be published.

## Excess Sulphuric Acid in Britain

After a year's consideration, a governmental committee makes the following recommendations for providing an outlet for the surplus acid to be expected on cessation of hostilities, according to the *British Board of Trade Journal*: Every possible step should be taken to extend the use of fertilizers. Farmers should be educated by lectures, demonstrations and experimental plots. Cheap freights should be arranged. A joint committee of zinc smelters, acid and fertilizer makers should endeavor to introduce Government-made acid to the market so as to produce a minimum of disturbance and to suggest means whereby the erection of new acid works to deal with the gases from zinc concentrates can be avoided. The following recommendations for the relief of present owners are made: that for the purposes of taxation, the rate of depreciation on acid plants should be increased to at least ten per cent, retroactive to Jan. 1, 1915; that a government committee determine a method of scrapping old plant,

government compensation to be paid on the basis of the value as a going concern, less scrap value; and that a reasonable rate of interest be allowed on plants which should be closed rather than scrapped. General recommendations of special interest to chemists are:

(a) In view of the importance of scientific control of chemical operations, we desire to draw attention to the need for improving the status of the technical chemist.

We consider that it is essential to the success of the chemical industries of the country that the value of men of liberal education who have specialized in chemistry and its cognate sciences and have experience of manufacturing operations should be more adequately recognized.

(b) We further recommend that the very complete data as to costs of production in acid manufacture and other chemical processes obtained by the Department of Explosives Supply during the war should be given as wide circulation as possible throughout the chemical trades, with a view to encouraging the more general adoption of a more systematic study of manufacturing costs.

## Heyden Chemical Works Seized by Alien Property Custodian

The second largest corporation of its kind in the United States was seized by the Alien Property Custodian when on July 29 he took over the Heyden Chemical Works at Garfield, N. J. It is claimed that the real owner of the business was *Chemische Fabrik von Heyden* of Germany, and that the true ownership was misrepresented or concealed. The following have been appointed officers and directors of the company: President, Leroy Baldwin, President Empire Trust Company, 120 Broadway; Vice President, James A. Branegan, chemist, 1421 Chestnut Street, Philadelphia; Secretary, F. N. B. Close, Bankers Trust Company, 16 Wall Street; Counsel, J. Harry Covington, former Chief Justice of the Supreme Court of the District of Columbia, and Royal H. Weller, ex-Assistant District Attorney, of 31 Nassau Street, New York.

## Chemists in France

Another tie joins France and American with the recent establishment of a French local section of the American Chemical Society.

Application has been made and granted for permission "to found in Paris a French section of the society covering the entire territory of France." The signatures on the application are those of distinguished French chemists intermingled with these of American chemists, who are now at the front in the service of our army. It is a joint brigading of French and American forces somewhat similar to that which has been affected recently between units of the respective armies. The successful result of the military union has already made itself evident on the battlefields of France and corresponding results can be predicted from this union of scientists.

## Koppers Company Stock For Sale

Custodian of enemy alien property, A. Mitchell Palmers offers for sale the stock owned by Heinrich Koppers of Essen, Germany, in the H. Koppers Company of Pittsburgh, which does a large business in designing, building and operating by-products coke ovens. The company is capitalized at \$1,500,000 and it is reported that 20 per cent of the stock will be sold.

## The Sexagesimal Trade Units

Factors and Factor Interrelations of Gallons,  
Pounds, Cubic Feet, and Gravities

SINCE the international introduction of the C. G. S. system of units 67 years ago, men of scientific training in the United States and Great Britain have sought to have our ancient trade units superseded by this more mathematically convenient system, which was so gloriously installed by the French at the time they cast out king and royalty, removed the spell of antiquity and thus started an age of scientific development in every field of the mental environments of mankind. The origin of the English trade units are buried deep in an unwritten history of the early commercial navigators. The pound undoubt dly came from the Roman *libre*, as a consequence of the military colonization of England by the Romans.

The numerical foundation of these trade units as a whole can well be called astronomical—the sexagesimal system was very popular with the star-gazers of Egypt, not only because of having the factors 1, 2, 3, 4, 5 and 6, but also because they expected to find some ultimate mathematical relationship between these numbers and the movements of the heavenly bodies. The lore of the astronomer had its economic value as well, perhaps, as its origin and development in guiding the traveler on the starlit sands of the Sahara and finally over sea and ocean. The numbers 7, 9, 11, and 13 gave these semi-magicians much trouble as they were—and are still by some—regarded with mystery. However, the ancient navigator certainly had a much wider education in the “1 to 6” multiples than we of the fingers-and-thumbs decimal age on casual thought credit him with having. For this reason, it would not be out of place to critically examine these familiar old units with the same point of view with which one would, were he transposed back to the dawn of science when the magician was closely scrutinizing the stars.

After the number 60, 12 seems to have been of greatest importance, perhaps because of the number of moons in the four seasons, perhaps also because it was devisable by all of the “1 to 6” excepting 5. The dozen became the trade count, the foot was divided into twelve parts, the medicines of the magician were divided by twelfths, and so on. What bearing the fact that 12 wine gallons of water weighs approximately one hundred pounds had to do with the origin of that unit may be left open to conjecture, as well as the fact that 60 pints equals one cubic foot; however, prior to the time of the manufacture of measuring instruments by skilled tradesmen the handy seven-inch diameter by six-inch high cylindrical container may have had some numerical origin in magical logic.

That they worked diligently compounding numbers is a well-known fact, and while they did not originate a system of units having the conveniences of the decimal C. G. S. system, nevertheless, their units were not absolutely without preconceived relation.

Most important of these relations of volumes and weights with reference to water are:

|                          |      |             |
|--------------------------|------|-------------|
| 1 cu.ft. of water weighs | 1000 | oz. avoird. |
| 1.6 “ “ “                | 100  | lbs. “      |
| 12 gal. “ “ “            | 100  | “ “         |
| 60 pints “ “ equals      | 1    | cu.ft.      |

The first relationship of ounces to cubic feet makes the solution of gas problems by Avogadro's Law as convenient with English units as with grams and litres. Thus an ounce-mol of any gas would make 22.4 cu.ft., etc. However, the C. G. S. system has taken undisputed possession of the laboratory, and it is only in trade metrology that any useful existing interrelations might prove valuable. Thus an ounce-mol of carbon dioxide, weighing 44 oz., would measure 22.4 cu.ft., as would 28 oz. nitrogen, 32 oz. oxygen, 29.2 oz. air, etc.

As the volume of 12 gallons or 1.6 cu.ft. of any substance weighs 100 times its gravity in pounds and the weight of any material to that of water is very easily determined by simple and well-known laboratory methods and for many substances is recorded in tables of specific gravities, it is easy to obtain weight per gallon or per cubic foot by pointing off the gravity two places and dividing by 12 for the former and 1.6 for the latter.

Thus if the specific gravity of a sample of  $H_2SO_4$  were found to be 1.44, the weight would be, per gallon,

$$\frac{144}{12} = 12 \text{ lb.}; \text{ per cubic foot, } \frac{144}{1.6} = 90 \text{ lb.}$$

Of course the specific gravity must be relative to water at 39 deg. F., or 62.5 lb. per cubic foot, which is approximately an average for good city water, though chemically pure water is one-quarter of one per cent lighter.

When the Baumé scales are used, the formulae employed to obtain the specific gravities would be as follows:

Lighter than water.

$$\text{Sp.Gr.} \frac{60}{60} = \frac{140}{130 + \text{deg. B}}$$

Heavier than water.

$$\text{Sp.Gr.} \frac{60}{60} = \frac{145}{146 - \text{deg. B}}$$

Thus, with a sample of 66° Baumé sulphuric acid:

$$\text{Sp.Gr.} \frac{145}{145 - 66} = 1.835$$

$$\text{Cu.ft.} = \frac{1.835 \times 100}{1.6} = 114.6 \text{ lb.}$$

$$\text{Gal.} = \frac{1.835 \times 100}{12} = 15.6 \text{ lb.}$$

By way of illustration to show the probability of the immediate introduction of the C. G. S. units into our trade, the resolution adopted by the National Association of Manufacturers at their recent convention may be noted:

WHEREAS, the agitation for the adoption of the metric system has been again revived and is being vigorously conducted, and

WHEREAS, the ‘British Committee on Commercial and Industrial Policy after the War’ has made an exhaustive analysis of this question and concludes in language as follows:

‘We are not convinced that the metric system is upon the whole even theoretically superior to the British system, and we are satisfied that the practical objections to the proposed change are such as to decisively outweigh any advantages which are claimed for it.

Therefore, be it

*Resolved*, that we regard the agitation for the establishment of the metric system as particularly untimely because of war taxation on manufacture, and because under present conditions the overwhelming activity of manufacturers in war work makes proper consideration of such a subject impossible. It is further

*Resolved*, that we endorse the work of the American Institute of Weights and Measures in opposing the adoption of the metric system.

# The Manufacture of Carbon Electrodes for Electrometallurgical Purposes\*

Raw Materials Suitable for Electrode Manufacture—Proportioning of Ingredients—Methods of Mixing and Firing—Testing the Finished Electrodes—Summary of Manufacturing Methods Used by Different Companies—Bibliography of Technical and Patent Literature

THE carbon electrode is the product of an industry which started about forty years ago. In the middle of the last century carbon plates and carbon pencils, principally as battery carbons, were made on a small scale, although manufacturing proper can only be considered to have begun about the '70's.<sup>1</sup> The credit for developing an industrial process of manufacture which is still used today in its general outline belongs to the Frenchman, Carré. In 1876 and 1877 he stated definitely the principal steps in his process: Grinding, mixing with a binding medium, pressing and afterward heating to incandescence. He introduced the idea of bedding the incandescent piece in coal dust and he was the first to manufacture artificial carbon industrially. The artificial carbons made at that time were used principally for illuminating purposes, but later they were employed for electrothermic processes. The industrial use of the electric arc in large furnaces as a source of heat, in the production of aluminium, the making of calcium carbide and ferro-alloys, as well as of electric steel, gave a great impetus to the manufacture of electrodes.

The demands made by electrothermic processes on the quality of artificial carbon are quite different from the requirements for obtaining a steady arc in electric lamps. Diffusion processes, such as making carbide and aluminium, require principally great mechanical strength, good conductivity and small losses. At the same time, the requirements in regard to dimensions were considerably greater than was the case for the manufacture of arc carbons or battery plates. This made it necessary to adjust the manufacture to the working of considerably larger quantities of material, and thus the manufacture of artificial carbon entered the circle of big industries. At the present time the

turnace installation of the large firms is of such size that it can be considered among the largest ceramic kiln installations existing. The machinery used is manifold and of quite considerable size. This is especially true of the hydraulic presses, used in the making of large electrodes.

The following notes describe the processes used in

some of the electrode factories, in so far as that is possible, following either the communications made by the respective factories or the data found in the literature. In general, the process consists in mixing the ground and cleaned raw material with tar, giving it the desired shape by pressing, and finally calcining the material to give it the required strength and conductivity. The manufacturing process is therefore in principal a very simple one, and in part is closely related to the general methods of ceramic manufacture. Whereas in the latter the binding medium is always a plastic clay, in the former the binding medium consists of pure carbon grains, the coke residue which remains after the calcination of tar or pitch-like substances.

The raw materials considered suitable for the manufacture of electrodes include all varieties of carbon found in sufficient purity and in a form which can be industrially used as such: Coke, charcoal, anthracite, lamp black, retort carbon, tar coke, petroleum coke and graphite. The proportioning of the quantities of the different ingredients and the size of the

grain are naturally of decisive importance for the quality of the final product. The manufacture begins with the crushing of the raw material in case that is necessary. As these substances are usually quite hard, it is necessary to provide extensive equipment for graded crushing, grinding and screening. Only a few of the numerous mill constructions have proved satisfactory, because the wear on the machinery is considerable if the wrong kind is chosen, and the presence of metallic iron in the smallest percentages must be avoided.

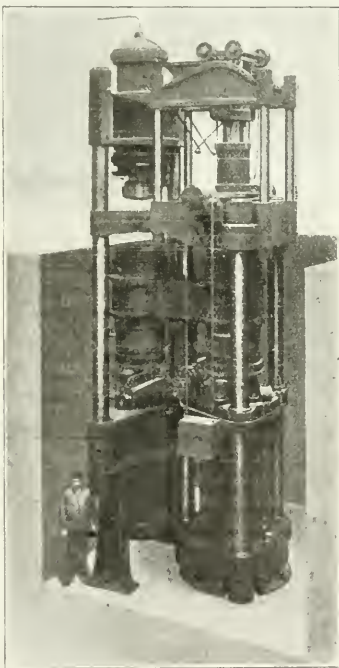


FIG. 1.—VERTICAL PRESS

\*Translation from *Stahl u. Eisen*, 32, 1912, p. 1857.

<sup>1</sup>On the historic development of the manufacture of electrodes—see Zellner: "The Artificial Carbons for Electrotechnical and Electrochemical Purposes, Their Preparation and Testing." Berlin, 1903, published by Julius Springer; further Tsch: "The Manufacture of Carbons for Electric Lighting and Other Purposes." London, 1899; *Zeitschrift für Elektrochemie*, 1901, 28, March, p. 516; *Elec. World*, 1909, v. 2, p. 682.

<sup>2</sup>See *Compt. Rendus*, v. 4; *Bull. de la Société d'Encouragement*, 1877; H. Fontaine, *L'Eclairage Electrique*, 1877.



The raw materials are subjected to calcination so as to remove all gases and oily substances. The crushed raw material is then mixed with the binding medium, tar or pitch, and kneaded. It is then given the required cross-section in a lever press as shown in Fig. 1.

The pressed pieces thus prepared are subjected to a roasting and coking process in a gas-fired angular kiln, with exclusion of atmospheric air. The kilns shown in

The process and installation of the Soc. Am. Electro-metallurgic Procédée Paul Girod, Ugine, are as follows: The principal raw products used by this firm for the manufacture of electrodes are: (1) Retort carbon; (2) petroleum coke; (3) anthracite. Pitch is used as a binding medium. These various raw products are used either separately or mixed in certain proportions, their selection depending upon the cost of production.

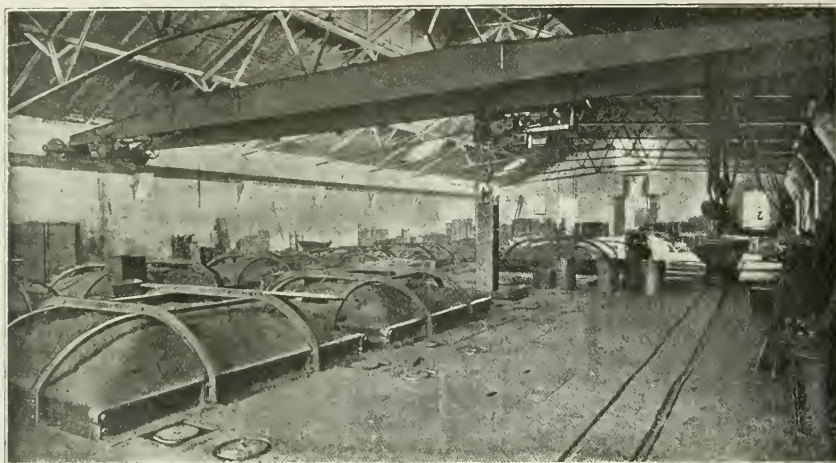


FIG. 2.—KILNS FOR BURNING ELECTRODES

Fig. 2 are generally low furnaces constructed of the best refractory material in order to withstand continuous temperatures of 1500 to 1600 deg. C. The exclusion of air is accomplished by placing the electrodes into square or round chambers of very refractory material and filling the space between electrode and chamber wall with carbon dust. The chambers are fitted with airtight covers. The period of calcination varies according to the dimensions of the electrode, being from six to twelve days for the smaller pieces and from ten to sixteen days for the larger ones. The firing must be extraordinarily uniform as otherwise stresses occur in the electrodes which easily lead to the formation of cracks.

During the first period of the calcination process the tar oils contained in the binding medium distill off, continuing up to the moment that red heat begins. Then the binding medium begins to coke and finally the whole mass begins to slag. The finished electrodes are removed from the furnace, and after complete cooling are examined for cracks or other faults, after which they are ready for use.

A German factory gives the following values for the physical and chemical qualities of amorphous carbon electrodes:

|                                                                            |                            |
|----------------------------------------------------------------------------|----------------------------|
| Specific weight                                                            | 1.50-1.55                  |
| Specific resistance at cross-sections of from 25 to 3000 sq. cm.           | 45 to 100 ohms             |
| Electrical coefficient of temperature of from 25° to 900° C.               | 0.000318                   |
| Specific heat determined at 100° C.                                        | 0.18-0.22                  |
| Compressive strength                                                       | 230-410 kg./sq. cm.        |
| Bending strength                                                           | 51-81 kg./sq. cm.          |
| Heat extension from 0-700° C.                                              | 0.26% of the initial value |
| Heat conductivity for a cube of 1 cm. at temperature falls from 130-20° C. | 0.24 heat unit st.         |
| Ash content                                                                | 2.5-3.0%                   |
| Phosphorus                                                                 | 0.45-0.53%                 |
| Sulphur                                                                    | 0.30-1.10%                 |

Retort carbon comes, as is well known, from obstructions formed in the retorts of gas plants. The ash varies from 1 to 3 per cent and contains little volatile substance. After its incineration, only small traces of ash are found and consequently this material can be used directly for the manufacture of electrodes without



FIG. 3.—RETORTS FOR DISTILLATION OF PETROLEUM COKE

preliminary treatment. Analysis of retort carbon is approximately as follows:

|                    | Per Cent |
|--------------------|----------|
| Ash...             | 1.77     |
| Volatile matter... | 0.46     |
| Sulphur            | 0.73     |

Petroleum coke, however, is different. This is a residue obtained from the distillation of heavy oils or petroleum oils, and still contains from 5 to 8 per cent of

\*On the raw materials for electrode manufacture; see also Zellner, *Stahl u. Eisen*, v. etc., p. 19-84.

volatile hydrocarbon. Hence it requires a special treatment consisting of further distillation before it can be used in the manufacture of electrodes. This distillation is carried out in furnaces with horizontal retorts similar in construction to the ovens used in gas plants (Fig. 3). Petroleum coke is heated in these retorts for about 6 hours at a temperature of 1000 deg. C., after which it contains only about 2 per cent of ash. In addition to

Anthracite is treated in about the same manner as petroleum coke because it also contains volatile matter. Its ash content amounts to about 2 per cent. The selection of the anthracite is more difficult than in the case of the two previously mentioned materials, because it is found to contain a strong admixture of iron oxide which is detrimental for the purposes to which the electrodes are applied. The composition of the anthracite used is ordinarily as follows:

|                           | Per Cent |
|---------------------------|----------|
| Ash .....                 | 2 77     |
| Volatile substances ..... | 6 30     |
| Sulphur .....             | 0 79     |
| Phosphorus .....          | 0 032    |
| Iron oxide .....          | 0 27     |

After these materials have been treated for the removal of volatile matter they are passed through a crushing and grinding plant and broken into grains of a size between 2 and 3 mm. They are then packed into sacks and weighed and are ready for the manufacture of electrodes.

The tar which serves as a binding medium is a mixture of pitch and tar oil, the quantity ratio of which must be kept exactly. It usually has the following composition:

|                       | Per Cent |
|-----------------------|----------|
| Ash .....             | 0 15     |
| Volatile matter ..... | 43 0     |
| Carbon .....          | 56 85    |

The composition of this tar is determined by two methods, both of which are of equal value and can therefore be used as checks. According to one method the volatile constituents and the ash and carbon contents are determined. According to the other the viscosity is measured, by determining the time required by a certain quantity of the tar to flow through a circular opening of known dimension.

The raw materials are then mixed in a steam jacketed mixing apparatus. The quantity of tar used varies between 22 and 30 per cent, depending upon the manufacturing process, i.e. if the electrodes are to be pressed or squirted out by a special press.

When the mass is sufficiently mixed it is further worked in mills as shown in Fig. 4, so that it becomes very dense. It is then put into the first press, shown in Fig. 5. Here it is pressed in a cylindrical container and has the shape of a block when freed from its mold. Such a block weighs approximately 1200 kg. After leaving the stamp press the block enters another special squinting press, shown in Fig. 6, where it is molded under pressure of from 380 to 400 kg. per sq. cm'. The extruded blocks will furnish from four to eight electrodes of the required diameter.

After leaving the special press the electrodes are set into an annular kiln, shown in Fig. 7, where they are embedded in coke dust in a vertical position in special earthen vessels. The calcination results in the distilla-

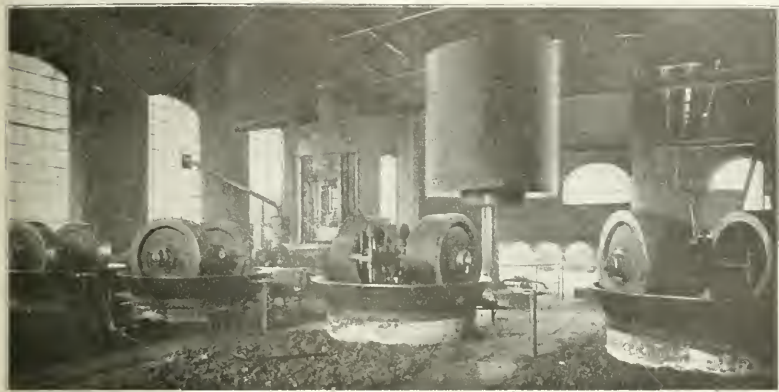


FIG. 4.—MILLS FOR WORKING RAW MATERIAL

this supplementary distillation, petroleum coke is subjected to a preliminary washing for the purpose of removing any soluble salt which it may contain. This work is carried out in chambers of 140 cu.m. capacity, there being six of these chambers at the plant. They are charged with coke and each of them is completely filled with water two or three times in succession so as to leach the soluble salt.



FIG. 5.—PRESS

The composition of petroleum coke is approximately as follows:

|                           | Before Washing,<br>Per Cent | After Washing,<br>Per Cent |
|---------------------------|-----------------------------|----------------------------|
| Ash .....                 | 3 09                        | 2 83                       |
| Volatile substances ..... | 6 55                        | 5 45                       |
| Sulphur .....             | 1 44                        | 1 34                       |
| Chlorine .....            | 2 36                        | 0 52                       |

\*On the mechanical working of carbon, crushing, mixing, pressing, see Zellner, p. 85-173.



tion of the volatile portion of the tar used as a binding medium, and the remaining carbon combines with the original grains to form the electrode.

The kiln consists of about thirty chambers, each with six vessels. It is heated by gas furnished by two gas

berg, describes electrode manufacture as follows:\*

The raw material, which is retort graphite from gas plants, is carefully freed from all impurities by brushing. For that purpose the pieces, often weighing hundreds of pounds, are crushed in rock crushers into pieces

about the size of the fist. They are then heated with exclusion of air to 1200 deg. C. so as to completely expel all volatile components. The pieces are then ground very fine and the powder is screened to uniform grains of the finest size, because it is of the utmost importance in the manufacture of electrodes that only very fine material should be used. The powder, free from dust, is very carefully mixed with tar, freed

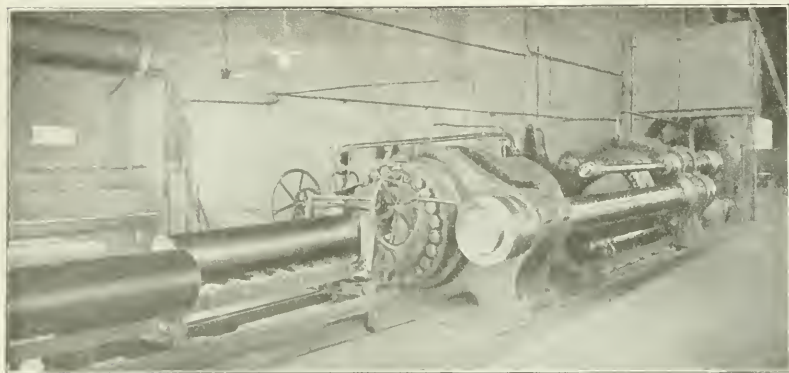


FIG. 6.—HORIZONTAL EXTRUSION PRESS

producers and is maintained at a constant temperature, rising from about 1100 to 1250 deg. C. It is of the utmost importance that the heating of the chambers should be regular and progress uniformly. The same is true as regards cooling. Any deviation from this rule means a failure in the product.

The results of analyses of the producer gas and the product of combustion in the kiln were as follows:

|                                                | Test I | Per Cent<br>Test II | Test III |
|------------------------------------------------|--------|---------------------|----------|
| At exit from gas producer:                     |        |                     |          |
| CO <sub>2</sub> .....                          | 4.5    | 6.3                 | 3.9      |
| O .....                                        | 2.2    | 2.3                 | 6.9      |
| CO .....                                       | 25.0   | 22.8                | 21.7     |
| Combustion product of gases at exit from kiln: |        |                     |          |
| CO <sub>2</sub> .....                          | 12.1   | 12.4                | 13.8     |
| O .....                                        | 5.8    | 6.0                 | 5.4      |
| CO .....                                       | 0.4    | 0.4                 | 0.0      |

It will be seen that products of combustion contain a small surplus of oxygen. It is very difficult to keep all of the openings airtight, especially if the kiln has been used for some time. The combustion of the gases in this case was evidently good, as the carbon monoxide content never exceeds 0.4 per cent.

After removal from the kiln the electrodes are brushed and examined. They must show no cracks and when tested by striking with a hammer must give a clear, pure tone.<sup>5</sup>

Some of the electrodes from each batch are taken for test and are examined for resistance in the test machine. Hitherto those tests were made by means of a milli-ampere meter, but that apparatus is too sensitive and is better suited for laboratory than for industrial purposes. The results obtained by this method were often impaired by intermediate resistances, as only weak currents were passed through the electrodes. It became necessary, therefore, to devise a machine which permitted of working with greater current and which yielded more exact and more uniform results.

The electrode factory of Dr. Albert Lessing, Nurn-

berg, describes electrode manufacture as follows:\*

The raw material, which is retort graphite from gas plants, is carefully freed from all impurities by brushing. For that purpose the pieces, often weighing hundreds of pounds, are crushed in rock crushers into pieces about the size of the fist. They are then heated with exclusion of air to 1200 deg. C. so as to completely expel all volatile components. The pieces are then ground very fine and the powder is screened to uniform grains of the finest size, because it is of the utmost importance in the manufacture of electrodes that only very fine material should be used. The powder, free from dust, is very carefully mixed with tar, freed from water, and heated for several hours in mixing machines, after which it is allowed to stand for some time. The shape of the electrode is given, according to the installation of the plant, either in large stamping machines which press the material into the required form in the cylinders of the electrode press, or in these same cylinders the mass is compressed by hydraulic means. It is necessary to envelop the cylinder with a steam jacket because after cooling of the tar the mass is quite stiff and not very pliant. It is, therefore, necessary to heat the mass throughout to about 40 deg. C. When this temperature has been reached, a mouth-piece is fitted to the open end of the cylinder which has an aperture exactly corresponding to the shape of the electrode, with  $\frac{1}{2}$  per cent added on account of the shrinkage during the further working of the mass. The electrodes thus compressed under the highest pressure are left for several days exposed to the air, after which they have hardened so much that they can be handled quite freely without breaking.

The electrodes are then placed in large kilns of the annular kiln type, situated underground so as to avoid the heat losses. Here begins the most difficult part of the manufacture, namely, the calcination at a temperature of 1300 deg. C. During this treatment the greatest care has to be taken, and in the best factories fourteen days are required for gradually heating the electrodes up to the maximum temperature and for the cooling which follows. The following reasoning shows how important it is to heat the material slowly. Carbon is a poor heat conductor. If the heating proceeds rapidly the outer layers will have been burned hard while the inner core will not have been sufficiently heated. The purpose of the calcination is to remove the tar which was previously added to increase the plasticity of the material. With too rapid heating, the tar in the interior would distil later and destroy the outer crust.

\*On the process of calcination (roasting), kiln, and kiln management, see also Zellner, p. 174-204.

"Zeitschrift für Elektrochemie," 1903, 26, March, p. 260.



It is necessary to examine the carbon carefully to detect large cracks. Small cracks on the surface only, so-called fire cracks, are of no importance. A flawless electrode, calcined to the core, should give a full sounding, clear, strong note when tapped with a hammer, whereas an electrode with cracks will have a sound like a broken pot.

The electrical resistance of such electrodes must be within narrow limits. It does not exceed 400 ohms per sq.mm., and 1 m. in length with the heaviest pieces, and with increasing cross-section it falls to 80 and 100 ohms. For many purposes the great chemical purity is of importance. On the other hand, small quantities of ash are of no importance in electrodes used in the manufacture of calcium carbide, since the raw materials, lime and coal, carry proportionately larger quantities of impurities into the finished product. It is evident also that the very pure electrodes are correspondingly expensive.

Clacher<sup>1</sup> has described the manufacture of electrodes in the factory of the British Aluminum Co. at Greenock, Scotland, as follows:

1. The petroleum coke is roasted to remove all volatile substances and increase its density and conductivity.
2. The roasted material is crushed.
3. The crushed material is mixed with a binding medium in a steam-heated mixer.
4. The mixed mass is shaped.
5. The block is calcined in a kiln which requires five days; after cooling the blocks are brushed and placed in the warehouse ready for delivery.

The petroleum coke contains from 5 to 13 per cent volatile hydrocarbon which escapes in the process of distillation; it contains further a small quantity (about 2 per cent) of inorganic substance. It is usually furnished by the oil plant in pieces of large dimensions, which is of great advantage, as the small coke and dust always present easily clog the roasting kilns, and thus only a small quantity of them can be used in a charge.

The kilns are arranged vertically, the coke being charged on top and the calcined material removed at the bottom. Charging is done every two hours, and each half hour a charge is removed, the coke requiring five hours to pass from the throat to the bottom. The temperature of the kiln at its hottest part reaches about 2000 deg. C. The process is very expensive with the method used at present, since 30 per cent of the coke charge is completely consumed. The volatile components of

the coke before calcination amount on an average to 8 per cent, so that 22 per cent of carbon is consumed to raise the temperature up to 2000 deg. C. The roasting was also done in horizontal retorts, the first cost of installation of which is greater, but the operation of which is more economical, the loss amounting to only 20 per cent. When the calcination was done in a flow of producer gas, the loss was somewhat higher than the percentage in volatile components of the material; the loss was 15 per cent with 10 per cent of volatile substances in the coke. The temperature is not so high as in the vertical retorts and does not much exceed 1000 deg. C.

After calcination the coke at Greenock contained 0.7 per cent of inorganic substances, as follows:

|                        | Per Cent |
|------------------------|----------|
| Silicic acid           | 0.50     |
| Iron oxide and alumina | 0.15     |
| Soluble sodium salt    | 0.05     |

The calcined coke is first crushed until the material all passes through a 9.5 mm. screen, after which it is ground to the exact powder grain size. This grinding is of the utmost importance. The quantity of fine and coarse grained powder must be in suitable proportion, so as to give a block of the highest density and least porosity. The following is a good mixture: 40 per cent of material screened through a 100-mesh screen; 15 per cent of material through a 60-mesh screen; 20 per cent through 30-mesh; 15 per cent through a 16-mesh, and 10 per cent through a screen of 8 to 16 mesh. The crushing is done in stone crushers and rapid running vertical mills. The cost of crushing at Greenock amounted to from 75c. to \$1 per ton.

The following raw materials are used at Greenock:

1. The residue blocks of the aluminium ovens which contain about 2 per cent of inorganic matter, of which a little more than 1 per cent is silicic acid and iron oxide. These blocks are crushed in the usual way to the grain size of an 8-mesh screen. The composition of the material is as follows:

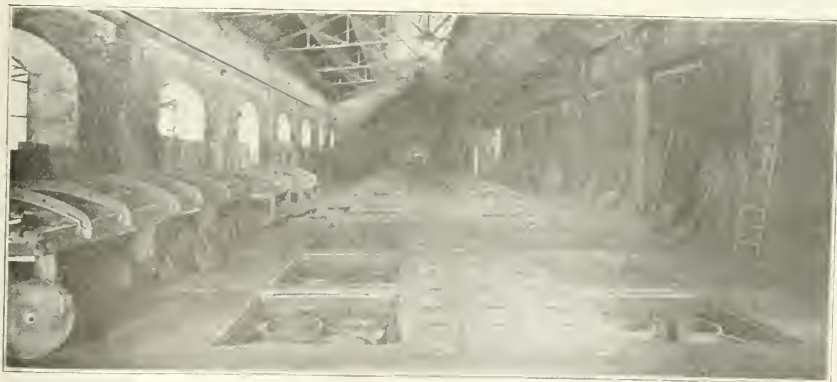


FIG. 7.—ANNULAR KILNS FOR CALCINING ELECTRODES

|                         | Before Working,<br>Per Cent | After Working,<br>Per Cent |
|-------------------------|-----------------------------|----------------------------|
| Ash                     | 1.56                        | 0.53                       |
| Soluble matter          | 0.33                        | 0.17                       |
| Silicic acid            | 0.46                        | 0.14                       |
| Iron oxide              | 0.26                        | 0.14                       |
| Clay                    | 0.39                        |                            |
| Lime, magnesia, sulphur | 0.12                        |                            |

<sup>1</sup>"The Manufacture of Carbon Electrodes." *The Electrical Rev.*, v. 68, p. 99. *Met. & Chem. Eng.*, 1911, March, p. 137.

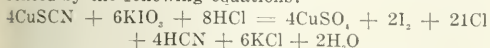


## The Determination of Copper in Insecticides\*

BY GEORGE S. JAMIESON

THE separation of copper as cuprous thiocyanate and its titration with a standard solution of potassium iodate in the presence of hydrochloric acid using an immiscible indicator such as chloroform as described by Jamieson, Levy, and Wells,<sup>1</sup> has been successfully applied to the estimation of copper in Bordeaux and Paris Green insecticides. When lead is present, it is necessary to remove it as the sulphate before proceeding to precipitate the copper. However, it has been found that arsenic did not interfere with the method.

The potassium iodate solution used in this investigation contained 11.7840 gr. of potassium iodate in 1000 cc. One cubic centimeter of this solution corresponded to 0.002000 gr. of copper. The reaction between the cuprous thiocyanate and the potassium iodate is represented by the following equations:



From 0.2 to 0.5 gr. of insecticide, depending upon the amount of copper present, was weighed into a No. 2 beaker. The powder was thoroughly moistened with about 10 cc. of water. About 5 cc. of sulphuric acid (1:3) was added and the solution was warmed to facilitate the decomposition. It was observed in some cases that a small amount of difficultly soluble material remained even after heating. No attention need be paid to this, as it caused no interference with the accuracy of the method. When the sample was completely decomposed, the larger part of the free sulphuric acid was neutralized with (1:1) ammonium hydroxide.

The solution which should now have a volume of 30 to 40 cc. was heated almost to boiling and treated with 10 cc. of strong sulphur dioxide water. Then 5 to 10 cc. of a 10 per cent solution of ammonium or potassium thiocyanate was added and the solution was stirred for 2 minutes. The precipitate was allowed to settle for 15 minutes before filtration. The cuprous thiocyanate may be filtered either on a close filter paper or on asbestos in a Gooch crucible as preferred. The precipi-

tate is washed with warm water until the soluble thiocyanate is removed. Owing to the slight solubility of the precipitate, care should be taken to avoid excessive washing.

Sometimes the cuprous thiocyanate will run through the filter. In such cases continue the filtration until the filter has become clogged and the filtrate is running clear, then refilter. No further trouble will be experienced.

The filter containing the precipitate is carefully removed from the funnel and folded so as to slip readily through the neck of the 250 cc. glass-stoppered bottle. Care should be taken not to occasion loss by allowing the fingers to come into contact with the precipitate. The precipitate adhering to the upper edge of the funnel or the Gooch crucible, the stirring rod, and the beaker is removed with small pieces of filter paper which are added to the titration bottle. A mixture of 35 cc. of concentrated hydrochloric acid and 20 cc. of water along with 7 cc. of chloroform are added. After each addition of potassium iodate solution, the stoppered bottle is thoroughly shaken. The rapidity with which the iodate solution may be added can be judged from the color changes of the aqueous solution and the chloroform. When the larger part of the iodine has disappeared, the titration should be continued carefully so as not to overtitrate the solution. The end point is the disappearance of the violet color from the chloroform. In order to prevent the hydrolysis of the iodine monochloride it is important to have a concentration of at least 10 per cent of hydrochloric acid in the solution at the end of the titration. According to the directions given above, enough hydrochloric acid is present so that 50 cc. of the iodate solution may be safely used without unduly lowering the acid concentration. For comparison the copper in the insecticides studied was determined by the thiosulphate method<sup>2</sup>.

The following results were obtained:

| Insecticide                   | Gr. Taken | Cc. of KIO <sub>3</sub> Used | Cu Found, Per Cent | Cu by Thiosulphate, Per Cent |
|-------------------------------|-----------|------------------------------|--------------------|------------------------------|
| Paris Green No. 12,542.....   | 0.1447    | 17.60                        | 24.27              | 24.33                        |
| Paris Green No. 12,542 . . .  | 0.1866    | 22.70                        | 24.33              | 24.34                        |
| Paris Green No. 12,542.....   | 0.2389    | 29.00                        | 24.27              | 24.31                        |
| Paris Green No. 12,542.....   | 0.4244    | 51.50                        | 24.27              | 24.26                        |
| Paris Green No. 12,489.....   | 0.2667    | 32.55                        | 24.41              | 24.45                        |
| Paris Green No. 12,489.....   | 0.2186    | 26.80                        | 24.46              | 24.45                        |
| Paris Green No. 12,489.....   | 0.3012    | 36.80                        | 24.44              | 24.44                        |
| Paris Green (a).....          | 0.2038    | 24.20                        | 23.75              | 23.79                        |
| Paris Green.....              | 0.3607    | 43.00                        | 23.84              | 23.92                        |
| Paris Green.....              | 0.2775    | 32.95                        | 23.75              | 23.82                        |
| Bordeaux Paris Green (a)..... | 0.8089    | 126.00                       | 18.79              | 18.76                        |
| Bordeaux Zinc (b).....        | 0.5121    | 48.18                        | 1.881              | 18.80                        |
| Bordeaux Zinc (b).....        | 0.4574    | 21.20                        | 9.27               | 9.29                         |
| Arsenic.....                  |           |                              |                    | 9.26                         |

(a) A. O. A. C. 1916 Reference Sample.  
(b) A. O. A. C. 1916 Reference Sample.

These test analyses show that the iodate method gives very satisfactory results. In view of the advantages that this method has over the thiosulphate procedure<sup>3</sup> it can be highly recommended for the determination of copper in insecticides.

Bureau of Chemistry,  
Washington, D. C.

A Georgetown, British Guiana, publication states that the Venezuelan Oil Concessions, Ltd., an English company, operating in Venezuela, has secured from the colonial office a large concession in the northwest district of British Guiana to explore for oil.

<sup>2</sup> J. Assoc. Off. Agr. Chem., 2 (1916), No. 1, Part II, p. 12.  
<sup>3</sup> J. Am. Chem. Soc., 30 (1908) 760.

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J. Am. Chem. Soc., 30 (1908), 760, Treadwell-Hall, 3 ed., vol. ii, p. 672.

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## Ilsemannite\*

### Results of a Study of a Blue, Water-Soluble Molybdenum Compound Occurring in Utah—Methods of Analysis and Results of Extraction Tests

By H. F. YANCEY

A DEPOSIT of considerable size of a molybdenum ore partially soluble in water has been found recently near Ouray, Utah. The ore is a sandstone containing the blue mineral ilsemannite. About one-half of the molybdenum in the ore is soluble in water, giving a deep blue solution. The geological features of this deposit have been investigated by Frank L. Hess of the U. S. Geological Survey; while Waldemar T. Schaller, also of the Survey,<sup>1</sup> has presented a preliminary report on the mineralogical aspects of the mineral.

In the present paper, the results of a brief study of the water-soluble blue compound are given, together with some results obtained in extracting the molybdenum from the ore. As ilsemannite is a comparatively rare mineral, very little is found in the literature regarding methods of extraction.

The blue ore found near Ouray, Utah, first attracted attention because of its property of giving a very deep blue color to water. Samples submitted to various assayers by a development company brought the report that it was without value. Because of the intense blue color of the water-soluble portion of the ore, this company thought that the blue solution might possibly be used as a dye. The company submitted samples to a dye-house which reported that the ore contained "molybdenum blue," an artificial compound sometimes used as a dye, and that the specimens sent them were probably "faked," as "molybdenum blue" was unknown in nature.

#### EARLY REPORTS ON ILSEMANNITE

Ilsemannite, a natural "molybdenum blue," was first reported as occurring at Bleiberg, Carinthia, by Hoefer in 1871,<sup>2</sup> who gave to it the name ilsemannite for J. C. Ilsemann (1727-1822), a German mining commissioner. It has also been reported by Lindgren and Ransome<sup>3</sup> as occurring in the Cripple Creek District, Colorado, and at Natal, South Africa, by duToit.<sup>4</sup> Horton<sup>5</sup> reports the occurrence of a molybdenum mineral having similar properties near Idaho Springs, Colorado.

The analysis of an air-dry sample from 90 pounds of the ore for the ordinary constituents gave the following results:

|                                              | Per<br>Cent |
|----------------------------------------------|-------------|
| Silica, SiO <sub>2</sub>                     | 65.92       |
| Total Iron as Fe <sub>2</sub> O <sub>3</sub> | 4.35        |
| Alumina, Al <sub>2</sub> O <sub>3</sub>      | 12.27       |
| Titania, TiO <sub>2</sub>                    | 0.35        |
| Lime, CaO                                    | 1.36        |
| Magnesia, MgO                                | 0.50        |
| Molybdenic Oxide, MoO <sub>3</sub>           | 1.22        |
| Total Soluble as SO <sub>3</sub>             | 11.00       |
| Moisture                                     | 1.11        |
| Loss on ignition                             | 4.80        |

The material evolves hydrogen sulphide with dilute hydrochloric acid, and when heated in a closed tube it gives voluminous fumes of sulphur dioxide. Vanadium and lead are entirely absent, or present only in minute traces. Large pieces of the ore have a blue-gray color. A small amount of material resembling mica is present.

#### CONSTITUTION OF ILSEMANNITE—HISTORICAL

The formula for ilsemannite generally given is MoO<sub>3</sub>.4MoO<sub>3</sub>. This formula was first given to a synthetic blue molybdenum compound by Berzelius. Hoefer<sup>2</sup> in naming a similar blue molybdenum mineral, ilsemannite, gave to it the formula of Berzelius, because the compound which was found in nature possessed similar properties. Various investigators have assigned different formulae to the synthetic molybdenum blue compound, but Guichard<sup>7</sup> in an exhaustive investigation has conclusively shown the formula to be MoO<sub>3</sub>.4MoO<sub>3</sub>, for the oxide anhydride, and the same formula with six molecules of water for the hydrate of the oxide. Several months after the publication of Guichard's paper, Bailhache<sup>8</sup> prepared two blue molybdenum molybdates by the interaction of the sulphate of the sesquioxide Mo<sub>2</sub>O<sub>3</sub>.2SO<sub>3</sub> with normal barium molybdate BaMoO<sub>4</sub>, and with barium heptamolybdate Ba<sub>7</sub>Mo<sub>7</sub>O<sub>41</sub>. The blue molybdates formed have the composition Mo<sub>2</sub>O<sub>3</sub>.2MoO<sub>3</sub>.6H<sub>2</sub>O, and (Mo<sub>2</sub>O<sub>3</sub>)<sub>3</sub>.(Mo<sub>2</sub>O<sub>3</sub>)<sub>4</sub>.18H<sub>2</sub>O respectively. Bailhache also states that it is possible to obtain other blue molybdates by the action of each of the series of barium molybdates on "molybdyle" sulphate, MoO<sub>3</sub>.2SO<sub>3</sub>. Guichard<sup>7</sup>, in a later paper, considers the method of preparation of the blue oxide by Bailhache and Klason<sup>9</sup> as interesting, but believes them to be identical with MoO<sub>3</sub>.4MoO<sub>3</sub>.6H<sub>2</sub>O.

Very few workers have investigated the constitution of the blue molybdenum compound occurring in nature, the mineral ilsemannite. As previously stated, Hoefer named the mineral ilsemannite, and gave to it the formula of the synthetic molybdenum blue of Berzelius. Muthmann<sup>10</sup> did not accept the formula of Hoefer for the mineral, stating that ilsemannite is MoO<sub>3</sub>.2MoO<sub>3</sub>. Schaller<sup>11</sup>, however, considers ilsemannite as a hydrous sulphate of molybdenum of the formula MoO<sub>3</sub>.SO<sub>3</sub>.5H<sub>2</sub>O, and suggests that this "formula be taken until further quantitative analysis on pure material shows a difference." Schaller also states that the water-soluble portion of the ore contains iron sulphate, and that the consumption of permanganate in titrating this solution exactly equals

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<sup>1</sup>J. Wash. Acad. Sci., 7, 417, 1917.

<sup>2</sup>N. Jahrb. Miner., 566, 1871.

<sup>3</sup>U. S. Geol. Survey, Prof. Paper No. 74, 121, 1906.

<sup>4</sup>So. African J. Sci., 13, 125, 1917.

<sup>5</sup>U. S. Bureau of Mines, Bull. 111, 15, 1916.

<sup>6</sup>Loc. cit.

<sup>7</sup>Ann. Chim. Phys. series 7, 23, 563, 1901.

<sup>8</sup>Compt. Rend. 133, 1210, 1901.

<sup>9</sup>Compt. Rend. 134, 173, 1902.

<sup>10</sup>Ber. d. chem. G., 34, 148-158, 1901.

<sup>11</sup>Liebig's Annalen, vol. 238, 1887, p. 108.

<sup>12</sup>Loc. cit.

the amount of iron (as ferrous iron), determined gravimetrically, and also that the intense blue color of the water-soluble portion is due to an undeterminable trace of molybdenum dioxide,  $\text{MoO}_3$ .

Confirmation of a portion of Schaller's work, particularly with respect to the amount of molybdenum in the reduced condition, and to the presence of molybdenum sulphate, has been impossible. Instead of finding an undeterminable trace of molybdenum dioxide, a sample from the same deposit shows as much as 12.5 per cent of the total molybdenum present to be in the reduced condition, assuming it to be present as molybdenum dioxide ( $\text{MoO}_3$ ). Schaller considers ilsemannite to be a hydrous sulphate of molybdenum, basing his formula on incomplete analysis of the water-soluble portion of the ore. It has been found that a somewhat more complete analysis of the water-soluble portion of the ore does not show the presence of sufficient sulphuric anhydride to combine with any of the molybdenum if the iron, aluminium, calcium and magnesium are assumed to be present as sulphates.

Schaller considers the intense blue color of the water-soluble portion of the ore to be due to an undeterminable trace of  $\text{MoO}_3$ , which he considers as having a very high coloring power. Ullik<sup>12</sup> in 1867 prepared impure molybdenum dioxide having a blue color in the crystalline form. The pure oxide according to later investigators is not blue, but brown or violet brown.<sup>14</sup> Muthmann<sup>15</sup> obtained pure molybdenum dioxide in opaque crystals having a violet reflex which were insoluble in boiling hydrochloric acid and caustic potash. It is, therefore, improbable that molybdenum dioxide is itself soluble in water, and that the blue color of the water-soluble portion of the ore is due to molybdenum dioxide alone. However, molybdenum dioxide is blue when in combination with the trioxide in the form of a double oxide or molybdenum molybdate; but the presence of only a trace of a lower oxide in combination with its equivalent of the trioxide is not enough to account for the blue color of the water extract of the ore.

#### DETERMINATION OF REDUCED MOLYBDENUM

The selection of a method for determining the quantity of molybdenum in the reduced condition in the water-soluble portion of the ore presented many difficulties. This is true because the water extract contains ferrous iron as well as reduced molybdenum. The blue molybdenum compound present is easily oxidized by the ordinary oxidizing agents. A reagent which would oxidize the iron without oxidizing the molybdenum could not be found. A solution of ferric iron oxidized the reduced molybdenum, and was most promising, but the reaction did not apparently proceed to completion until the addition of a considerable excess of ferric iron. Again, the oxidation of the reduced molybdenum by ferric iron is somewhat slow. It was then considered advisable to find a method of separating the iron in the water extract of the ore from the blue molybdenum compound. Ninety-five per cent alcohol dissolved the blue material of the ore, but at the same time also dissolved the ferrous iron. Absolute alcohol was next tried, but this would dissolve only a very small amount

of the blue compound and some ferrous iron. Guichard<sup>16</sup> states that molybdenum molybdate  $\text{MoO}_3 \cdot 4\text{MoO}_3$  is soluble in alcohol, but not in ether. He also says that below certain concentrations, sulphuric and hydrochloric acids diminish the solubility of the blue double oxide in water without altering its composition. Diethyl ether did not extract the blue compound from the ore, nor from the blue water-soluble portion of the ore. However, when sulphuric or hydrochloric acid was added to the blue water solution, the solubility of the blue compound was diminished, and the blue color of the water layer was partially transferred to the ether layer on shaking. Under certain conditions to be described later, and by washing the ether extract with dilute hydrochloric acid, it is possible to completely remove the iron from the blue compound which remains dissolved in the ether. The ether may then be evaporated and the reduced as well as the total molybdenum determined.

The method used to determine the reduced molybdenum in the ether extract was to allow the ether to evaporate at room temperature until nearly all had evaporated. The remainder was then evaporated rapidly *in vacuo*, the process being continued for a time in order to remove all hydrochloric acid. The blue compound was then dissolved in water, filtered, and titrated with hundredth-normal permanganate, 5 cc. of 1:1 sulphuric acid being added to the blue water solution. The reduced molybdenum was calculated as  $\text{MoO}_3$ . A negative correction for a blank determination was applied to the titration in the following manner: Hydrochloric acid and ether of the same volumes as used in the extraction were shaken together, separated, the ether evaporated and titrated with permanganate. The total molybdenum in the same solution was determined by evaporating the solution to fumes with sulphuric acid, diluting with water, and then adding an excess of sodium hydroxide solution. The precipitate of manganese hydroxide is filtered off, and examined for traces of iron. It is not usually necessary to make a reprecipitation at this point. The filtrate is acidified with sulphuric acid, about 2½ per cent excess acid being added, and the molybdenum determined by passing the hot filtrate through the Jones reductor, according to the method of Randall.<sup>17</sup>

#### EXTRACTION OF THE BLUE COMPOUND WITH ETHER

Two hundred grams of ore was extracted successively with small portions of hot water until the volume of the filtrate was 500 cc. Most of the water-soluble blue material was removed by this treatment. An aliquot of 200 cc. was transferred to a separatory funnel, and 50 cc. of hydrochloric acid (conc.) added. The mixture was then cooled under the water tap, and 200 cc. of ether added. This was shaken vigorously, and cooled during the shaking. The layers of ether and water were then allowed to separate, and the water layer drawn off into another separatory funnel, and again extracted with 100 cc. of ether. After separation of the two layers, the ether extracts were combined, and washed ten times with 10 cc. of concentrated hydrochloric acid diluted to 25 cc. with water. Acid of this concentration dissolves but a very small portion of the blue compound originally extracted by the ether. The acid washings were tested for iron, and the process discontinued when

<sup>12</sup>Liebig's *Annalen*, 144, 227, 1867.

<sup>14</sup>Guichard, *Compt. Rend.*, 129, 722, 1899.

<sup>15</sup>Liebig's *Annalen*, 238, 114, 1857.

<sup>16</sup>Loc. cit.

<sup>17</sup>*Amer. Jour. Sci.*, 21, 313, 1907.

all was removed. After the washing was complete, the ether extract was allowed to stand for about two hours to complete the separation of suspended dilute acid. This was then drawn off, and the reduced and total molybdenum determined.

The extraction process as outlined does not remove all of the blue compound from the water solution. This may be accomplished by increasing the concentration of hydrochloric acid, and then extracting about three times more with 100 cc. portions of ether. However, if all the blue compound is extracted, it will be found impossible to wash all of the iron out of the ether extract, and ferric iron will be formed. The ferric iron will oxidize some of the reduced molybdenum, and the per cent of molybdenum in the reduced condition will be lowered.

It was found that when the blue material was totally extracted by ether from the water layer that all of the molybdenum was at the same time removed. This would indicate that the blue material is a compound, and, therefore, of definite composition. It at least possesses the property of being completely soluble in ether saturated with hydrochloric acid. All attempts to show definiteness of composition by extracting a given aliquot in two stages, and determining the per cent reduced molybdenum in each extract failed, because it was impossible to remove the iron from the second and complete extraction of the blue color from the water.

Numerous determinations showed that the blue material extracted by ether contained from 11.5 to 12.5 per cent reduced molybdenum, assuming the reduced molybdenum to be present as molybdenum dioxide ( $\text{MoO}_2$ ). This amount of reduced molybdenum accounts for 50 per cent of the water-soluble blue compound, which is extracted by ether if it be present in the heretofore accepted form of molybdenum molybdate ( $\text{MoO}_3 \cdot 4\text{MoO}_3$ ). The blue material extracted by ether, after removal of iron, does not give a test for sulphates. As about one-half of the blue compound, from a given volume of water extract, may be removed by ether, then at least one-half of the water-soluble molybdenum may be obtained free of sulphates. The only reason that all of the water-soluble molybdenum may not be obtained free of sulphates is because the ether extract cannot be washed free of iron sulphate if all of the "molybdenum blue" is removed from the aqueous layer.

#### DIRECT TITRATION

In view of the results just given, and their marked difference from those obtained by Schaller,<sup>18</sup> it was considered advisable to determine the amount of reduced molybdenum in the water-soluble portion of the ore by the direct titration of the water solution. Schaller found that direct titration of this solution with permanganate exactly equals the amount of iron (as ferrous iron) determined gravimetrically.

Determination of reduced molybdenum in the water solution by direct titration with permanganate, and then the determination of total iron and total molybdenum, and calculation of the amount of reduced molybdenum from the difference between the iron and the direct titrations involves the assumption of the absence of ferric iron. Tests for ferric iron on freshly prepared water extracts of the ore with molar am-

monium thiocyanate solution were negative. If one milligram of ferric iron in 1 cc. of water be added to 9 cc. of the blue solution, and a few drops of thiocyanate solution be added quickly, the characteristic red coloration is produced. As soon as the ferric iron solution is added to the blue solution, the blue color becomes less intense, due to the oxidation of the blue compound. However, the rapid addition of thiocyanate suffices to detect the presence of that portion of the original milligram of ferric iron remaining unreduced. If the thiocyanate is not added quickly, the iron added is reduced, and does not give the red coloration.

Tests on the water-soluble portion of the ore for sulphur dioxide and hydrogen sulphide were negative. As ferric iron is also absent, the direct titration method as outlined should give an accurate determination of the amount of reduced molybdenum.

By quickly preparing and titrating the water-soluble material from 200 grams of the ore in five equal aliquots with standardized permanganate solution, 12 per cent of the total molybdenum present was found to be in the reduced condition. This figure agrees very well with the amount of reduced molybdenum determined by the ether extraction method. The iron in the same aliquots was determined by reducing with zinc (reductor), and titrating with the same solution of permanganate. The total molybdenum was determined in the filtrate from the iron (two precipitations) by the method already given.

#### ANALYSIS OF WATER-SOLUBLE MATERIAL

A quantity of ore (250 grams) sufficient to approximately saturate 100 cc. of water was boiled with the water for about twenty minutes. This was then filtered, washed with 50 cc. of cold water, and evaporated to dryness. The dark blue solid was dried at 105 deg. C., and examined quantitatively for the ordinary radicals with the following results:

|                                      | Per Cent |
|--------------------------------------|----------|
| Silica, ( $\text{SiO}_2$ )           | 9.98     |
| Alumina, ( $\text{Al}_2\text{O}_3$ ) | 10.62    |
| Ferrous oxide, ( $\text{FeO}$ )      | 9.58     |
| Titania, ( $\text{TiO}_2$ )          | trace    |
| Calcium oxide, ( $\text{CaO}$ )      | 1.24     |
| Magnesium oxide, ( $\text{MgO}$ )    | 1.36     |
| Sulphur trioxide, ( $\text{SO}_3$ )  | 38.48    |
| Molybdic oxide, ( $\text{MoO}_3$ )   | 23.85    |
| Chlorine, ( $\text{Cl}$ )            | 0.17     |

This is not a complete analysis. The sample analyzed contained 1.10 per cent moisture, as determined by drying at 150 deg. C. for one hour. The loss on ignition was 43.8 per cent, but this represents a loss of molybdenum, and possibly water of hydration.

If all of the iron oxide, alumina, lime and magnesia are present as sulphates, one gram of the material would require 0.4010 grams of sulphur trioxide. One gram would contain only 0.3848 grams of sulphur trioxide. However, some silica and a small amount of chlorine are present. On this basis the 23.85 per cent molybdic oxide (total Mo calculated as  $\text{MoO}_3$ ) could not be in the form of a sulphate. Schaller proposed his sulphate formula for ilsemanite without determining alumina, lime and magnesia if present in the sample examined by him.

#### MISCELLANEOUS PROPERTIES OF THE BLUE SOLUTION

Qualitative ionic migration experiments on the water-soluble portion of the ore showed that the blue color behaved as a cation. With a current of 80 milliamperes,

<sup>18</sup>Loc. cit.



the movement toward the negative electrode is apparent after about 30 minutes. Other carriers, however, were present in the agar-agar blue layer besides the blue compound, as the blue water extract of the ore was used in making up the tube. With a small amount of hydrochloric acid present in the blue layer, a similar effect was noted. The results would seem to indicate that the cation of the blue compound is also blue, and that probably the  $\text{MoO}_2$  ion is acting as the positive carrier, though the effect may denote colloidal migration. Guichard<sup>28</sup> states that the molybdate of the dioxide of molybdenum ( $\text{MoO}_2 \cdot 4\text{MoO}_3 \cdot 6\text{H}_2\text{O}$ ) is a colloid. In this connection, it is interesting to note that the similar divalent compound of uranium, the uranyl radical ( $\text{UO}_2$ ) has decidedly basic properties, and that on electrolysis of its salts the uranyl ( $\text{UO}_2$ ) ion migrates to the cathode.<sup>29</sup> Among the members of Group VI of the periodic classification, which included molybdenum, the dioxides  $\text{R}^{\text{VI}}\text{O}_2$ , of the members of low atomic weights, sulphur, selenium and tellurium are acidic or neutral. As the atomic weight of the elements increase, the basicity of the radical  $\text{R}^{\text{VI}}\text{O}_2$  also increases, and the compounds formed become more stable. Brownish violet molybdenum dioxide ( $\text{MoO}_2$ ) united with white or yellow molybdic oxide ( $\text{MoO}_3$ ) to form blue molybdenum molybdate ( $\text{MoO}_2 \cdot 4\text{MoO}_3$ ); brown tungsten dioxide ( $\text{WO}_2$ ) interacts with yellow tungstic oxide ( $\text{WO}_3$ ) to form blue and purple-red tungsten tungstates; while brown uranium dioxide ( $\text{UO}_2$ ) and brownish-red uranic oxide ( $\text{UO}_3$ ) form green and black uranium uranates.

Guichard<sup>28</sup> prepared molybdenum dioxide by electrolysis of molten molybdic oxide, and Junius<sup>30</sup> has obtained blue molybdenum molybdate of the formula  $\text{Mo}_2\text{O}_7$ , at the cathode by the electrolysis of molybdic oxide in strong hydrochloric acid.

One-half gram of ammonium molybdate was evaporated nearly to dryness with sulphuric acid. After standing some time, the characteristic molybdenum blue color developed. Extraction of the blue color with ether in the presence of hydrochloric acid showed that only 8 per cent of the molybdenum had been converted into the blue compound. The remaining molybdenum sulphate was not nearly so soluble in ether as the blue of ilsemanite. If the blue of ilsemanite is molybdenum sulphate, then it should not be entirely soluble in ether saturated with hydrochloric acid. However, as pointed out under the section "Extraction of the Blue Compound with Ether," it is entirely extracted by ether.

The blue water extract makes an excellent ink, though it is slowly oxidized in the air. The blue color of the writing is discharged by hydrogen peroxide, but reappears if moistened with stannous chloride solution. Sulphur dioxide does not produce analogous results.

#### CONCLUSIONS

The above work does not constitute a basis for the proposal of a formula for ilsemanite. The formula proposed by Schaller<sup>23</sup> ( $\text{MoO}_3 \cdot \text{SO}_3 \cdot 3\text{H}_2\text{O}$ ) is not supported by the present investigation. Muthmann's<sup>24</sup> formula ( $\text{MoO}_2 \cdot 2\text{MoO}_3$ ) more nearly fits the properties of the

compound as determined, but requires perhaps too much reduced molybdenum. Guichard<sup>28</sup> has shown the formula of Muthmann for the synthetic blue oxide ( $\text{MoO}_2 \cdot 2\text{MoO}_3 \cdot x\text{H}_2\text{O}$ ) to be inaccurate; that it really is  $\text{MoO}_2 \cdot 4\text{MoO}_3 \cdot 6\text{H}_2\text{O}$ . But even Guichard's formula does not fit the blue of ilsemanite completely; as the water-soluble portion of the molybdenum in the ore does not contain sufficient reduced molybdenum. However, it is preferable for the present to consider the ore examined as a mixture containing the original parent molybdenum mineral, and water-soluble ilsemanite of Guichard's formula together with other water-soluble oxides of molybdenum formed in the alteration process.

#### EXTRACTION OF MOLYBDENUM FROM THE ORE

The methods employed in treating the ore are divided into four general classes: Extraction with water, extraction with dilute acids, with dilute alkali carbonates and alkalies, and by roasting with a small amount of various reagents followed by a water leach. Obviously fusion methods, such as are being used on wulfenite concentrates, would not be commercially applicable to a one per cent molybdenum ore.

It is not intended to convey the impression that all or any of the methods given could be used profitably in extracting molybdenum from the ore. A problem of this nature, of necessity, depends on many conditions outside of the laboratory. It is hoped that suggestions given here may be of some use if other conditions warrant the development of this deposit of ilsemanite.

Unless otherwise noted, the ore used in the following experiments was of the following size: Thirty-five per cent is retained on 40 mesh screen; 35 per cent passes 40 mesh, but is retained on 80 mesh, and 30 per cent passes 80 mesh.

#### LEACHING EXPERIMENTS WITH WATER AND ACIDS

The plan followed in determining the per cent of molybdenum that could be extracted by water was as follows: A sample of the ore (10 grams or more) was treated with successive portions of water, until the filtrate from the water leach showed little or no blue color. The water solution was then oxidized with nitric acid, the blue color disappearing, taken to fumes with sulphuric acid, diluted, and made alkaline with sodium hydroxide. The precipitate was filtered off, the filtrate made acid with sulphuric acid, heated to about 70 deg. C., and passed through the Jones reductor into a solution of ferric ammonium sulphate decolorized with a few cc. of syrupy phosphoric acid. This was then titrated with standard potassium permanganate to a one-half-minute pink. In order to determine the solubility of the ore in a large excess of water, one gram was leached with 150 cc. of hot water. The residue was dried at 105 deg. C.; 4.34 per cent of the ore was found to be soluble. The residue contained a little less than 15 per cent molybdic oxide.

If 10 grams of ore is treated with three successive portions of hot water of 30 cc. each, coming to a boil each time, between 46 and 54 per cent of the molybdenum in the ore is removed. These results have been confirmed by numerous trials.

In order to determine the quantity of ore required to give the highest concentration of molybdenum in a given

<sup>28</sup>Loc. cit.

<sup>29</sup>Roscoe and Schorlemmer II, 1108, 1913.

<sup>30</sup>Am. Chim. Phys. series 7, 23, 563, 1901.

<sup>31</sup>Zeit. Anorg. Chem., 46, 428, 1905.

<sup>32</sup>Loc. cit.

<sup>33</sup>Loc. cit.

<sup>34</sup>Loc. cit.

volume of water, separate portions of 5, 10, 15, 20 and 25 grams of the coarser mesh ore were treated with 10 cc. of water each. The water was allowed to come to the boiling point, when the entire contents of each beaker were placed on separate filters. The residues on the paper were then washed with 10 cc. of cold water, and the molybdenum content of the filtrates determined. The results are given below:

|                                            |     |     |     |     |     |
|--------------------------------------------|-----|-----|-----|-----|-----|
| Grams of ore.....                          | 5   | 10  | 15  | 20  | 25  |
| Cubic centimeters of $\text{KMnO}_4$ ..... | .17 | .27 | .34 | .36 | .38 |
| Per cent Mo extracted.....                 | .46 | .40 | .33 | .28 | .23 |

These results show that saturation has not been quite reached, but that approximately one part of water requires from two and one-half to three parts of the ore. The cc. of  $\text{KMnO}_4$  used in the data tabulated above refers to molybdenum present in the water-solution. One cc.  $\text{KMnO}_4$  is equivalent to 0.00132 grams Mo; per cent Mo extracted means the per cent of the total present extracted.

#### EXTRACTION OF THE ORE WITH COLD WATER

Twenty-five grams of the ore, and 10 cc. of water at room temperature were allowed to stand for one hour. The solution was then filtered off, and the Mo in the filtrate determined. The residue was leached one hour with another 10-cc. portion of cold water, filtered, and the Mo determined. This operation was repeated four times in all. The result are as follows:

| Extraction No.             | 1   | 2   | 3  | 4  | Total per cent of Mo extracted |
|----------------------------|-----|-----|----|----|--------------------------------|
| Per cent Mo extracted..... | .12 | .15 | .3 | .4 | 2.5 33.5                       |

To determine whether a finer mesh would permit the extraction of a larger per cent of the molybdenum, a portion of the sample above mentioned was ground to pass 150 mesh. This was then extracted with hot water along with a sample of the coarser material. After three hot water leaches of 30 cc. each, the residues were extracted with 50 cc. of hot 15 per cent sulphuric acid. The results are given below:

|                                                                  | Coarse mesh | 150 mesh |
|------------------------------------------------------------------|-------------|----------|
| Per cent extraction Mo hot water.....                            | 54          | 57       |
| Additional per cent extraction Mo in hot 15% sulphuric acid..... | 16          | 27       |
| Total extraction water and acid.....                             | 70          | 84       |

It will be noted that fineness of the ore does not materially increase the percentage extraction in the case of water, but that it does increase it if the water leach is followed by sulphuric acid. Perhaps with additional acid leaches all of the molybdenum might be extracted. Ten grams of ore leached successively with three 30 cc. portions of hot water followed by 50 cc. of 1:1 ammonium hydroxide gave an extraction of 63 per cent; while the same weight of ore leached with two 50 cc. portions of 1:1 ammonium hydroxide gave only a 39 per cent extraction.

#### COMPARATIVE RESULTS ON LEACHING WITH WATER AND ACIDS

Additional leaching experiments with water and acids on both the coarse-mesh ore and the 150-mesh ore gave results as indicated in Table I; in each case 10 grams of ilsemaninite and boiling reagents were used.

The best results are given by 5 per cent sulphuric acid. It will be observed that the finer mesh ore gives much better yields with all acids; also that in most instances a preliminary treatment with water followed by acid gives a somewhat better yield than the reverse

TABLE I—LEACHING EXPERIMENTS

| Treatment of Ore                                                                                                                                                    | Per Cent Mo Extracted |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------|
| No. 1. Coarse mesh ore leached with two 30-cc. portions of boiling water, followed by 50 cc. of 5% boiling $\text{H}_2\text{SO}_4$ , then 10 cc. of cold water..... | 67                    |
| No. 2. 150-mesh ore, same treatment as above.....                                                                                                                   | 80                    |
| No. 3. Coarse ore leached with 50 cc. boiling 5% $\text{H}_2\text{SO}_4$ , then two 30 cc. boiling water, then 10 cc. cold water.....                               | 68                    |
| No. 4. 150-mesh ore, same treatment as coarse ore above.....                                                                                                        | 83                    |
| No. 5. Coarse ore, two 30 cc. water, then 20 cc. 15% $\text{H}_2\text{SO}_4$ , 10 cc. cold water.....                                                               | 64                    |
| No. 6. 150-mesh ore, treated as No. 5.....                                                                                                                          | 79                    |
| No. 7. Coarse ore, 20 cc. 15% $\text{H}_2\text{SO}_4$ , then two 30 cc. water followed by 10 cc. cold water.....                                                    | 62                    |
| No. 8. 150-mesh ore, same as No. 7.....                                                                                                                             | 76                    |
| No. 9. Coarse ore, two 20 cc. water, 20 cc. 5% $\text{HCl}$ , 10 cc. cold water.....                                                                                | 64                    |
| No. 10. 150-mesh ore, same as No. 9.....                                                                                                                            | 80                    |
| No. 11. Coarse ore, 20 cc. 5% $\text{HCl}$ , two 20 cc. water, then 10 cc. cold water.....                                                                          | 61                    |
| No. 12. 150-mesh, same as No. 11.....                                                                                                                               | 83                    |
| No. 13. Coarse ore, two 20 cc. water, 20 cc. 2% $\text{HNO}_3$ , 10 cc. cold water.....                                                                             | 70                    |
| No. 14. 150-mesh ore, same as No. 13.....                                                                                                                           | 79                    |
| No. 15. Coarse ore, 20 cc. 2% $\text{HNO}_3$ , two 30 cc. water, 10 cc. cold water.....                                                                             | 70                    |
| No. 16. 150-mesh, same as No. 15.....                                                                                                                               | 77                    |

treatment. It is improbable, however, that a process involving the use of 150-mesh ore could be used commercially. It was also determined that reduction of the sulphuric acid concentration much below 5 per cent gives such a poor extraction as to render it useless.

#### LEACHING EXPERIMENT WITH AQUEOUS CAUSTIC SODA AND SODIUM CARBONATE

Ten grams of the ore with 0.25 grams of sodium carbonate and 50 cc. of water were heated to boiling, and the soluble material then filtered off. The residue in the beaker was washed by decantation with two 25-cc. portions of boiling water. The molybdenum in the aqueous extract was then determined, and the per cent of the total present that had been removed computed. This experiment was then repeated, using sodium hydroxide instead of sodium carbonate, exactly the same amount as those given above being used.

| Per cent Mo Extracted..... | $\text{Na}_2\text{CO}_3$<br>60 to 66 | $\text{NaOH}$<br>78 to 82 |
|----------------------------|--------------------------------------|---------------------------|
|----------------------------|--------------------------------------|---------------------------|

The color of the sodium carbonate extract was blue, but that of the sodium hydroxide extract was brown to yellow, filtering with more difficulty than the carbonate. The ratio of the weight of reagent to that of the ore is equivalent to 50 pounds of reagent per ten of ore. Using 25 pounds of sodium hydroxide per ton of ore in exactly the same manner as the above, an extraction of 67 per cent was obtained.

An experiment on a larger scale using 50 pounds of minus 30-mesh ore and 1.25 pounds of sodium hydroxide in 200 pounds of water gave an extraction of 72 per cent of the molybdenum, calculated on the basis of the heads and tails.

In addition to the wet methods used above, the ore was roasted with various reagents at a temperature below 600 deg. C. Sodium chloride, sodium nitrate, sodium pyrosulphate and charcoal were tried alone, and in mixtures of one part of reagent or mixtures of reagents to ten parts of ore. The sintered cake resulting was then extracted with hot water. In no case was the extraction improved over that of hot water alone. The extraction of molybdenum varied from 16 to 28 per cent.

I desire to express my thanks to Dr. R. B. Moore, under whose direction the above work was carried out, and to Dr. S. C. Lind for a number of helpful suggestions.

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Golden, Colorado.

# The Metallography and Heat Treatment of Metals Used in Aëroplane Construction—II

## Investigation of Parts Made From Medium-Carbon, High-Carbon and Chrome-Nickel Steels—Causes of Failure in Cam Wheels, Piston Pins and Crank Shafts

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### MEDIUM-CARBON STEEL

THIS steel is called forging stock and from it are made propeller hubs, wing plates, strut sockets, hinges, both male and female, bolts, etc. Average chemical analysis: Carbon 0.35, manganese 0.65, sulphur 0.04, and phosphorus 0.032 per cent.

The raw stock has the following physical properties:

|                        |        |
|------------------------|--------|
| Ultimate strength, lb. | 80,800 |
| Yield point, lb.       | 54,600 |
| Elongation, per cent.  | 33     |
| Reduction, per cent.   | 62     |
| Brinell                | 153    |
| Scleroscope            | 30     |

Heat treatment of 1550 deg. quenched in oil and drawing at 965 deg.

|                        |        |
|------------------------|--------|
| Ultimate strength, lb. | 96,000 |
| Yield point, lb.       | 68,090 |
| Elongation, per cent.  | 29     |
| Reduction, per cent.   | 68     |
| Brinell                | 194    |
| Scleroscope            | 36     |

The principal defects found in this type of steel are pipes and slag inclusions. The pipe shown in Fig. 32 was heated at a temperature of 1600 deg. for one hour and a half in an attempt to improve it. There was no marked change. Material of this type will grow worse or the pipe will grow on usage. This illustration is of interest because it is thought by some that heat treatment will do away with pipes.

This material has given less trouble than any other as it responds very nicely to heat treatment, i.e., gives the necessary physical properties, and there have been few rejections from slag, pipes, excess phosphorus or sulphur.

On several occasions this stock has been mixed with nickel steel. The separation was brought about by taking a small section from each rod and quenching all at a temperature of 1500 deg. and scleroscoping. The nickel scleroscoped about 60, and the carbon steel 40.

One or two illustrations were found of a brittleness that was probably caused by the pickling operation. The reaction of the acid on the steel gave off hydrogen which was absorbed and gave rise to the defect. Concentrated caustic solutions at a boiling temperature used for removing the quenching oils also gave a slight attack, as in the case of the pickling.

Some tests have shown a variance in crystal size. This depends on many factors, principal of which are the temperature of the steel prior to rolling, the deformation during rolling, the finishing temperature, and the rate of cooling.

Owing to the many variables it is difficult to arrive at any accurate method of calculating the strength of a steel of this type from the chemical analysis. The following data give a fairly good approximation.

**Carbon**—In acid steel each 0.01 per cent carbon strengthens the steel by 1000 lb. per square inch. In basic steel each 0.01 per cent strengthens the steel by about 700 lb. per square inch.

**Phosphorus**—Each 0.01 per cent strengthens the steel by about 1000 lb. per square inch.

**Manganese**—In acid steel each 0.01 per cent above 0.4, about 200 lb. per square inch. *Basic steel*, about 90 lb. per square inch.

The strength derived from manganese increases as the carbon content decreases.

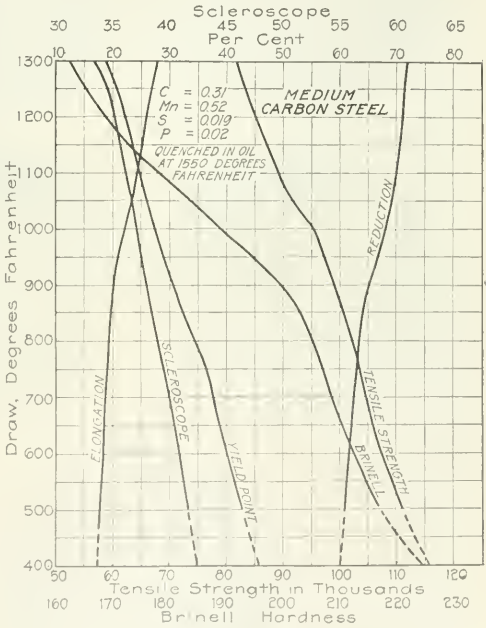


PLATE 2.—PROPERTIES OF MEDIUM CARBON STEEL

**Sulphur**—Practically has no strengthening effect. Formula—Acid Steel:

$$40,000 + 1000C + 1000P + 200Mn = \text{Raw stock.}$$

Basic Steel:

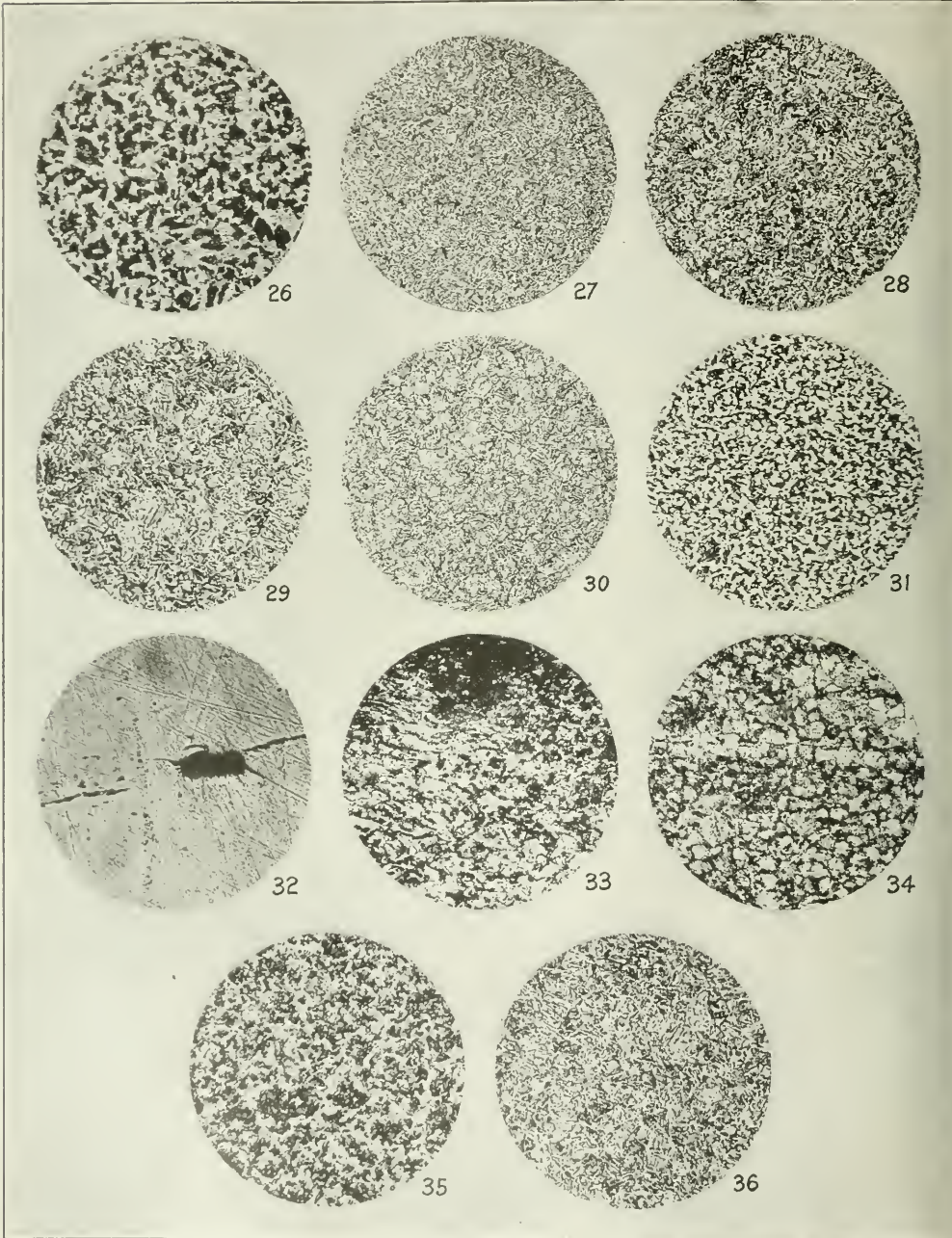
$$42,000 + 700C + 1000P + 90Mn = \text{Raw stock.}$$

Raw stock + 33 per cent = Quenched stock.

Quenched stock—2000 lb. for each 100 deg. draw.

A cam wheel on showing peculiar properties (softness, distortion) after being used was investigated to





FIGS. 26-36

Figs. 26-31—Medium Carbon Steel, Analysis: C, 0.35 per cent; Mn, 0.65; P, 0.01; S, 0.032. Etched with picric acid; x 100. Fig. 26—annealed; 27—quenched; 28—quenched and drawn at 800 deg.; 29—quenched and drawn at 1000 deg.; 30—quenched and drawn at 1200 deg.; 31—raw stock. Fig. 32—Pipe in medium carbon steel. Fig. 33—Section taken through cam on wheel. Fig. 34—Section of wheel some distance from cam, showing general structure. Fig. 35—Control lever before quenching and drawing. Etched with picric acid; x 100. Fig. 36—Control lever properly treated.

determine the cause of said properties. This material was supposed to be medium carbon steel cyanided at 1600 degrees for ten minutes and quenched in water.

The wheel was first scleroscoped carefully, then sections were taken and quenched and again scleroscoped. Near the cam a section was taken; then one some distance away. These were polished, etched with picric acid and photographed at a magnification of 100. The photomicrographs are shown in Figs. 33 and 34. The scleroscope test of the wheel, as received, gave 27; after quenching in water at 1475 deg., 29; quenching at 1550 deg., 31. A chemical analysis gave the following results: C, 0.09 per cent; Mn, 0.37; S, 0.101; P, 0.112; Fe, 98.

*Summary*—The material is very poor and has been slightly case-hardened on the bearing or concave surface.

Fig. 34 shows that it is very low carbon stock with a very poor structure as one would expect from screw stock (high S and P).

Fig. 33 taken from the cam shows where the material is distorted by usage; also slightly carbonized. It would be impossible to handle such material in any way to get satisfactory results.

An excellent material for this part is chrome-nickel steel. By heat-treating it will give all of the necessary properties and will be superior to any carbon steel.

CONTROL LEVER INVESTIGATION

This lever on being placed in the machine bent and was too soft for service. It was supposed to have been made of medium carbon steel (0.32 per cent) and quenched at 1550 deg. in oil and drawn at 1000 deg.

The object of the investigation was to determine if possible the explanation of the objectionable properties. A chemical analysis showed C, 0.31 per cent; Mn, 0.55; S, 0.046 and P, 0.023.

Scleroscope 28 and Brinell 145.

A section was taken, polished, etched with picric acid and photographed at a magnification of 100. This section was then taken, quenched at 1550 deg. and drawn at 1000 deg. This was also photographed.

Fig. 35 shows the lever as it was and Fig. 36 shows it properly treated.

*Summary*—The lever had been annealed (Fig. 35) and left in that condition. A proper heat treatment of about 1550 deg. quench in oil and draw at 1000 deg. would have shown a scleroscope hardness of 35 to 40 and a Brinell of 195 to 210. Fig. 36 shows the structure of the material properly handled.

It is well at this point to take into consideration the use of the scleroscope. This is a very valuable piece of apparatus in connection with heat-treating. It is recommended that the material be scleroscoped before and after heat treating.

*Precautions in using:*

- 1. Instrument should be mounted on a firm base in good light.
- 2. A good smooth surface with a fine file are necessary.
- 3. Round specimens should be tested on the end and not the curved surface.
- 4. Take the mean of several readings.
- 5. Do not take two readings in the same place—shift the apparatus.

HIGH-CARBON STEEL

Tail-skid shoes, cable wire, and some springs are made from high-carbon steel. There is considerable trouble in heat-treating this steel as it will crack when quenched cold. It is preferable to heat to the quenching temperature (1450 deg.) and after quenching remove from the oil before cold or while it has a temperature of probably 200 deg. This will give a slight draw-back and will relieve any strains. Hot water has been used with good results on this material. Oil gives a better and tougher result than can be obtained from any other quenching medium.

The chemical analysis of this stock is 0.93 per cent C, 0.35 Mn, 0.016 S, and 0.035 P. By lowering the

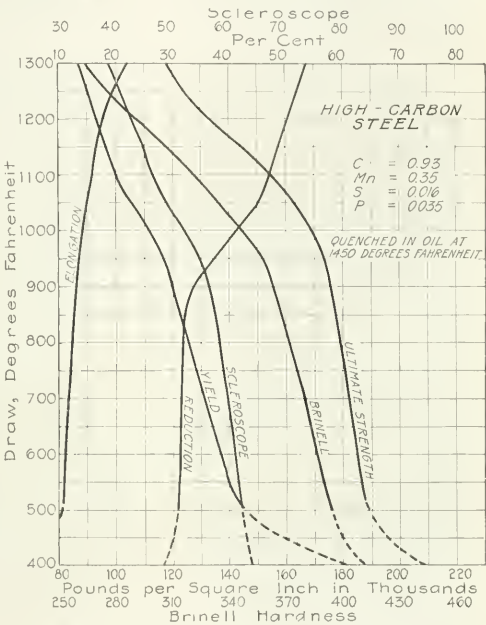


PLATE 3.—PROPERTIES OF HIGH CARBON STEEL

carbon to about 0.55 and increasing the manganese to 0.85 there will result as good a material if not better for shock-resisting properties.

Raw stock physical properties:

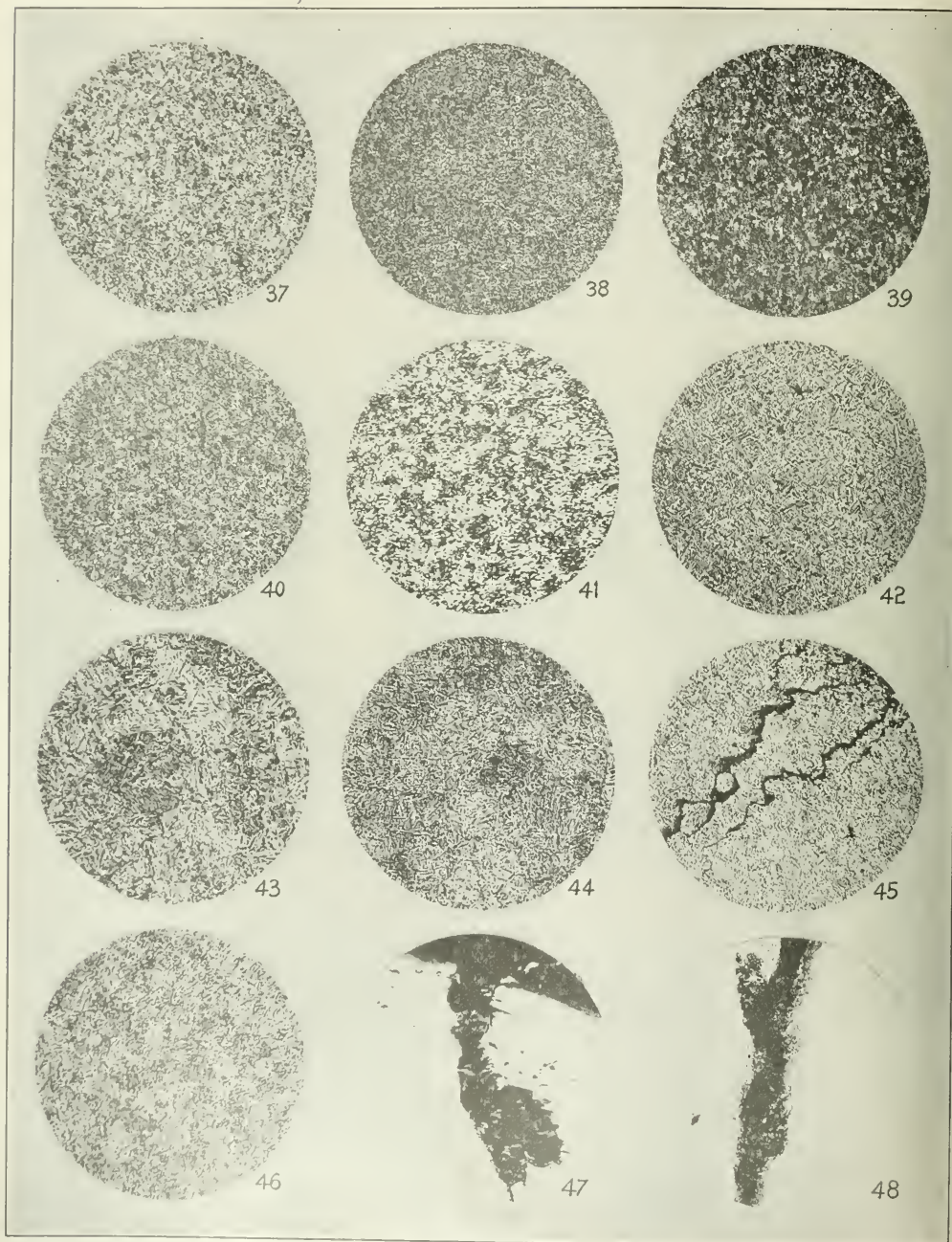
|                        |         |
|------------------------|---------|
| Ultimate strength, lb. | 113,000 |
| Yield, lb.             | 72,200  |
| Reduction, per cent.   | 38      |
| Elongation, per cent.  | 20      |
| Brinell                | 223     |
| Scleroscope            | 38      |

Quenched at 1450 deg. in oil and drawn at 650 deg.:

|                        |         |
|------------------------|---------|
| Ultimate strength, lb. | 184,000 |
| Yield, lb.             | 132,000 |
| Reduction, per cent.   | 33      |
| Elongation, per cent.  | 11      |
| Brinell                | 385     |
| Scleroscope            | 60      |

Cable wire has a high tensile strength. In some instances it is too hard to comply with the bend tests in which case it is slightly drawn at from 450 to 600 deg. Much of this material has been rejected because of fine cracks which were probably caused from trying to obtain a too high tensile strength by straining in cold drawing.





FIGS. 37-48

Figs. 37-40—High Carbon Steel. Analysis: C, 0.93 per cent; Mn, 0.35; S, 0.016; P, 0.025. Etched with picric acid; x 100. Fig. 37—quenched; 38—quenched and drawn at 800 deg.; 39—quenched and drawn at 1000 deg.; 40—quenched and drawn at 1200 deg. Figs. 41-44—Chrome Nickel Steel. Analysis: C, 0.30 per cent; Si, 0.19; Mn, 0.51; S, 0.029; P, 0.042; Cr, 0.61; Ni, 1.79. Etched with picric acid; x 100. Fig. 41—raw stock; 42—quenched; 43—quenched and drawn at 1000 deg.; 44—quenched and drawn at 1200 deg. Fig. 45—Hardening cracks in piston pin. Etched with picric acid; x 100. Fig. 46—Sorbite structure of piston pin drawn at 350 deg. Fig. 47—Inclusion showing as hair line in surface of crank shaft. Fig. 48—Inclusion in same shaft some distance from Fig. 47.



High tension or aviation wire and cable of an average analysis of 0.75 per cent C, 0.60 Mn, 0.032 P and 0.027 S, has a tensile strength of about 250,000 lb. per sq.in. The ends of these wires and cables are made into loops and soldered.

When soldering the loops on the ends of wire and cable, due care should be exercised not to draw or anneal the steel. It is good practice to have some kind of a temperature control on the soldering baths, if used instead of irons or in connection with irons. Acid fluxes cause corrosion especially when the cables are on sea planes and salt water comes in contact with the part already affected. Where acid attacks the surface of the steel, the weakened area formed by the corrosion acts like a file cut, and vibration soon causes the rest, resulting ultimately in rupture under strain.

CHROME-NICKEL STEEL

Chrome-nickel steel is made into piston pins, connecting rods and crank shafts, steam-line wire, etc.

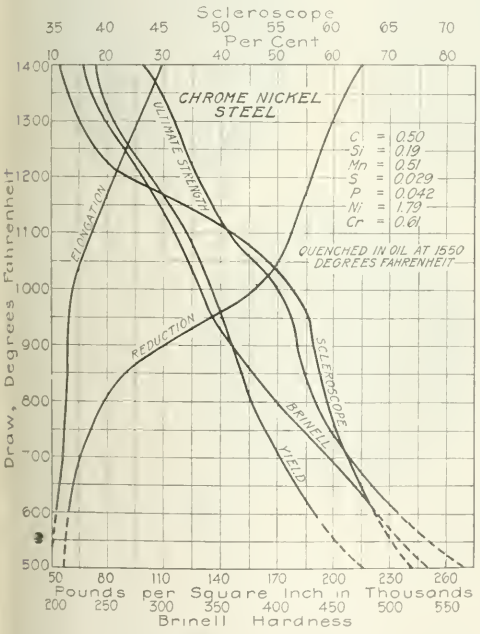


PLATE 4.—PROPERTIES OF CHROME NICKEL STEEL

It is good to resist shock and has a high tensile strength. The presence of both chromium and nickel produces a steel that has a high elastic limit combined with increased elongation and reduction, greater hardening power, and wears much better than carbon steels. This steel is especially valuable in parts that necessitate a heat treatment as it yields a fine martensitic structure superior to carbon steels. It resembles the 3 1/4 per cent nickel steel when carbonized in that it may be quenched at about 1550 deg. and refine both the case and core at the same operation.

A typical chemical analysis of this type of steel is C 0.30 per cent, Si 0.19, Mn 0.51, S 0.029, P 0.042, Ni 1.79, and Cr. 0.61.

Raw stock physical properties:

|                       |         |
|-----------------------|---------|
| Ultimate tensile, lb. | 122,000 |
| Yield, lb.            | 108,800 |
| Reduction, per cent.  | 55.8    |
| Elongation, per cent. | 13.0    |
| Brinell               | 255     |
| Scleroscope           | 40      |

Quenched at 1550 deg. and drawn at 900 deg.:

|                       |         |
|-----------------------|---------|
| Ultimate tensile, lb. | 180,000 |
| Yield, lb.            | 150,000 |
| Reduction, per cent.  | 40      |
| Elongation, per cent. | 13      |
| Brinell               | 360     |
| Scleroscope           | 56      |

There has been some trouble in heat-treating this material, piston pins especially often showing hardening cracks. It is sometimes a good plan to double-quench this material before drawing, at 1575 deg. then at 1500 deg. in oil or hot water, being careful to quench the pins vertically. This seems to give a much better result.

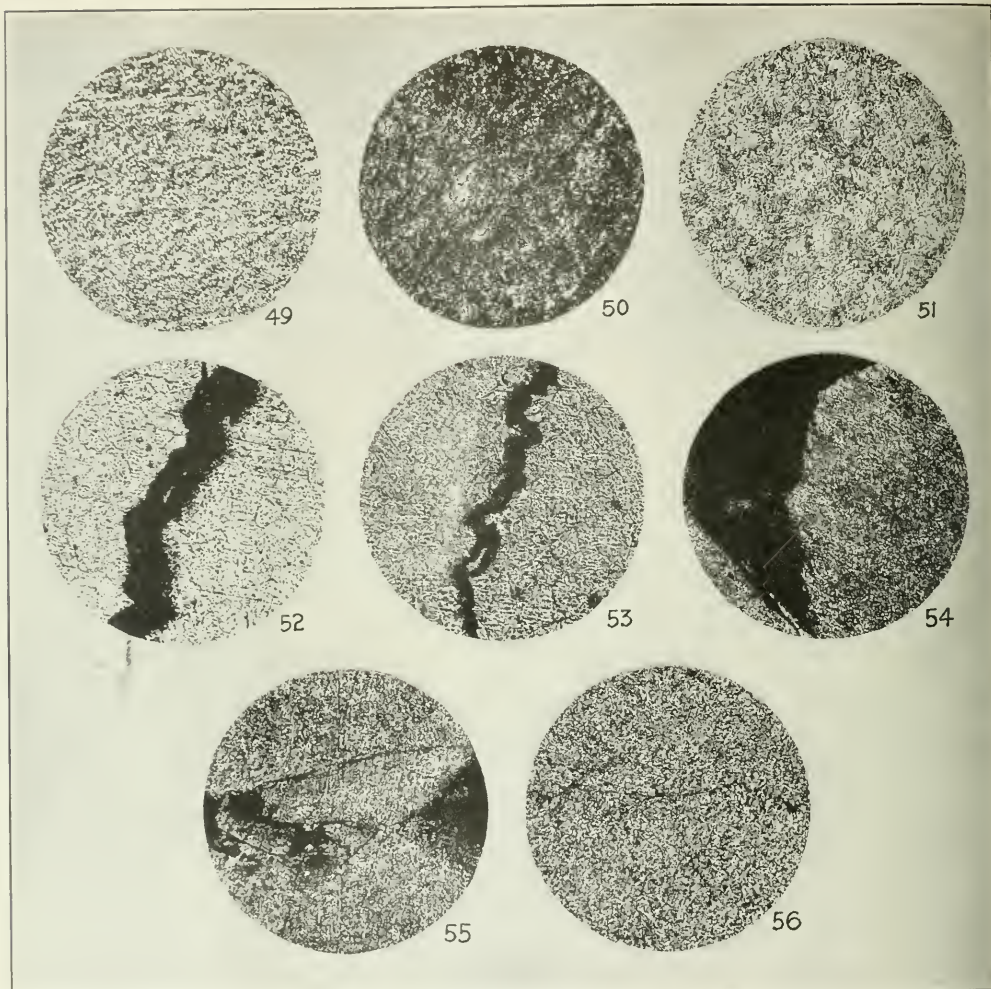
The following is a typical illustration of poor heat-treating of this kind of steel. A piston pin broke after a ten-hour run in a motor. The section showed a hardness of 79, and on being drawn at 850 deg. for thirty minutes scleroscoped 55. The photomicrographs (Figs. 45 and 46) show that the pin was too hard and that it was full of hardening cracks, eight being found. The section that was drawn showed a sorbitic structure in which the ferrite has followed the original martensitic needle lines.

**Summary**—The chemical analysis of this pin was C 0.38 per cent, Mn 0.51, S 0.026, P 0.018, Ni 3.24, and Cr. 1.25. This is very good, and where there are no bad inclusions or seams, pins should not crack when quenched and drawn as before suggested. The pins investigated were probably quenched cold which set up internal strains that yielded the hair cracks. It was apparently not drawn.

Crank shafts made of chrome-nickel steel often contain hair lines or inclusions of manganese sulphide and silicate. They are objectionable due to the fact that they form surface cracks that will have a destroying effect on soft metal bearings; also they form slight lines of weakness. Cranks of this type will often give satisfactory results, but where the inclusions are of the size shown in Figs. 47 and 48 they should be regarded with suspicion, especially so when found in the "cheeks" of the shaft.

In considering the acceptance or rejection of such a shaft the location, size and type of inclusion should be taken into consideration. The inclusion shown in Fig. 48 was about 0.022 in. in depth and in case of its occurrence in a part of the shaft subject to torsion there is no question but that there is danger of failure, especially when there is poor alignment of bearings. These defects result from poor metallurgy, but by the proper proportioning of Al, Si, and Mn, could be done away with. This would increase the piping but this defect could be removed in the discard. The so-called snow flake does not occur in shafts of this analysis. The particular shaft that showed these hair lines had a composition of C 0.33 per cent, Mn 0.64, P 0.026, S 0.038, Cr 0.78, Ni 1.32 and had the following physical properties:

|                        |         |
|------------------------|---------|
| Ultimate strength, lb. | 150,000 |
| Yield point, lb.       | 120,000 |
| Elongation, per cent.  | 18      |
| Reduction, per cent.   | 56      |



FIGS. 49-56

Figs. 49 and 50—Mixed structure in crank shaft resulting from poor heat treatment. Photos taken at some distance from each other. Fig. 51—Same section as Fig. 49 given proper heat treatment. Figs. 52 and 53—Hair-line cracks in crank shaft due to improper quenching. Fig. 54—Pipe in gas pocket in crank shaft. Fig. 55—Torsional cracks in crank shaft. Fig. 56—Snow flake, due to forging at too low temperature.

Another shaft investigated failed in service. Sections taken from it had a chemical analysis of C 0.39 per cent, Mn 0.78, S 0.034, P 0.012, Ni 1.42, and Cr 0.82, and physical properties as follows:

|                           |         |
|---------------------------|---------|
| Ultimate tensile, lb..... | 142,000 |
| Yield point, lb.....      | 125,000 |
| Elongation, per cent..... | 18.7    |
| Reduction, per cent.....  | 55.4    |
| Brinell.....              | 256     |
| Scleroscope.....          | 48      |

From one end of this shaft to the other there was a variance of 42 to 52 on the scleroscope and 241 to 256 on the Brinell. The photomicrographs showed a mixed structure which probably resulted from poor heat treatment.

Figs. 49 and 50 were taken from the shaft at some distance apart, etched with nitric acid and photographed at a magnification of 100.

Fig. 51 shows the section illustrated in Fig. 49 after having been given proper treatment—a very fine sorbite. Quenched at 1600 and 1500 deg. in oil and drawn at 900 deg.

The shaft failed because of poor heat-treatment varying the physical properties of the shaft. It might also have been assisted by the bearings not being true. This has been found true in other cases of failure.

Some shafts are spoiled by quenching improperly. This gives rise to hair-line cracks. Hair-line cracks must not be confused with hair-line inclusions. The quenching medium should not be too rigid or abrupt, as cold water. Figs. 52 and 53 show hair-line cracks. They were about one-fourth of an inch deep and are sufficient cause for rejection. Shafts should be quenched in oil or warm water.



The faults in the shaft shown in Fig. 54 are due to a poor billet. They are pipes or gas pockets and probably could have been avoided by a larger discard. The serrated lines here shown in Fig. 55 are probably torsional cracks. This is a very serious defect, much more so than inclusions.

Snow flake as shown in Fig. 56 is a fault arising probably from forging at too low a temperature. It is a condition peculiar to steel of a higher nickel content.

#### CRANK SHAFT SUMMARY

The inclusions shown are of manganese sulphide and silicate. Sulphur prints show considerable discoloration from these areas.

Some shafts have stood up very well after a 100-hour run, while others show that cracks have begun to grow from the inclusions and still others have failed entirely, the failure being traced to the inclusion. As these inclusions can be avoided, and since they are unquestionably lines of weakness and do cause failures, why argue over their acceptance?

Hair cracks are sometimes traced from quenching in cold water. Sometimes they are started by improper

forging (forging strain). The cracks shown between the gas pockets in Fig. 54 would appear as hair cracks. Heat-treatment when not conducted properly will give a bad shaft. Variance of temperature in the furnace and crude quenching methods are the principal factors. Some pyrometers are found to be incorrect as much as 200 to 300 deg. F. Too much attention cannot be paid to the proper treatment of crank shafts. The gas pockets shown may be secondary pipes and the cracks connecting the pockets may be pipe-cracks (expansion and contraction). A pipe generally can be removed by properly discarding the top section of the ingot, by bottom pouring, or by the use of molds having a greater top diameter than bottom. In the case of green steel there are local gas pockets and this illustration may be one.

Snow flakes occur in this steel because of poor mill practice. The manufacturer in trying to rush the heat sometimes pours while green. This will sometimes give a condition as here shown. Furthermore, if a high-nickel bar of this steel be forged at too low a temperature there might be a condition such as this. I prefer to think that the fault herein shown traces its origin to poor mill practice.

(To be continued)

The First Veritable Platinum Ingot was made by a French chemist, Chabaneau, in 1783. Charles III of Spain had called him to Madrid and created a special chair of mineralogy, physics, and chemistry for him. Here in his laboratory he found the secret for rendering the new metal malleable, and astonished the court by the weight and lustre of his first ingot.

## Developments in Industrial Research\*

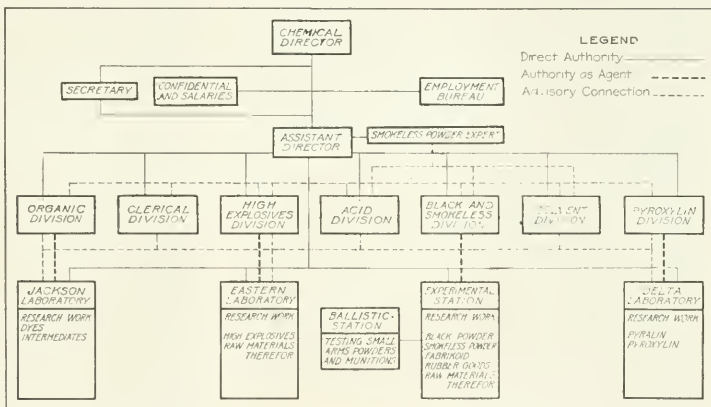
By CHARLES L. REESE

Chemical Director, E. I. duPont de Nemours & Co.

THE duPont Company started its research department June 1, 1902, by establishing what is known as the "Eastern Laboratory," at Gibbstown, N. J. A force of five chemists, including the Director, constituted its personnel. The Director's duties were two-fold: First, directing laboratory research work, and second, studying chemical operations of the high explosives plants.

In 1903, a second experimental laboratory, known as the "Experimental Station," was established in Wilmington to handle work specifically for the development department of the company. This was later extended to include also work in connection with the manufacture of black and smokeless powder.

In 1912, the "Delta Laboratory" was established for the purpose of investigating problems in connection with the manufacture of pyralin or celluloid, and in 1917 the "Jackson Laboratory" was established in connection with



PLAN OF RESEARCH ORGANIZATION

the dyes industry. All these experimental laboratories were placed either at, or in close proximity to manufacturing plants, in order to facilitate the study of plant problems.

Very soon after the establishment of the Eastern Laboratory, it was found desirable to have a head of the research department at the main office in Wilmington, Del., where the duPont Company's executive work is centralized, in order to provide a clearing house for the several research laboratories, and to have available a force of expert chemists who could not only keep in touch with actual manufacturing operations at the various plants, but who could act in a consulting capacity to the various departments. At the same time it was found advisable to centralize all chemical research work under one Chemical Director, and accordingly the Experimental Station, which had been connected with the development department, became a part of the chemical department organization.

\*Delivered at the meeting of the American Society for Testing Materials, Atlantic City, June 26, 1918.



The growth of the research activities since the establishment of the Eastern Laboratory in 1902 is well shown by the following tabulation, which gives the number of salaried employees, and the salaries paid per month during the last ten years:

|                    | 1908     | 1909   | 1910   | 1911   | 1912   | 1913   | 1914   | 1915   | 1916   | 1917   | June, 1918 |
|--------------------|----------|--------|--------|--------|--------|--------|--------|--------|--------|--------|------------|
| Employees..        | 55       | 75     | 92     | 111    | 111    | 115    | 95     | 160    | 200    | 395    | 475        |
| Salary per month.. | \$ 8,000 | 10,000 | 12,000 | 13,000 | 14,000 | 14,500 | 13,000 | 20,000 | 26,000 | 55,000 | 92,000     |

Not only has the number of salaried employees increased considerably during these ten years, but the salary rates have very decidedly increased, although this is not true of the average salary per man, due to the increased proportion of younger men employed during the last few years. Furthermore, as indicated by the accompanying curve, the total yearly expenditures for research work have grown from fifty thousand to two million dollars. This growth in research activity shows clearly that the duPont Company considers its research department a distinctly profitable undertaking.

During the period from 1912 to 1915, the total expenditures for research work amounted to approximately one million two hundred thousand dollars; while the total savings, direct or indirect, accomplished by this expenditure were fourteen million dollars. It is, of course, difficult, in fact almost impossible, to calculate the exact pecuniary saving brought about by many lines of research, but the above figures, which represent only savings which could definitely be traced to research activities, give some idea of the magnitude of what can be accomplished.

The diagram shows graphically the present organization of the chemical department of the duPont Company. In addition to the chemical force, which is directly engaged in research work, and which is represented by the chemical department with its several branches, the company employs a large number of graduate chemists in its various plants, either in plant laboratory work, or in the supervision of its chemical manufacturing operations. The total number of chemists employed at present, including those in the research department, is approximately eleven hundred.

#### DIRECT AND INDIRECT FINANCIAL RETURNS

The first important problem undertaken by the research department, when established, was a study of a difficulty met with in works operations, in the separation of nitro-glycerine from waste nitrating acid. After a few months' study this problem was solved by the discovery of the presence of colloided silica in certain brands of glycerine, which colloided silica hindered the separation of the nitro-glycerine from the acid. It was found that by the addition of minute quantities of sodium fluoride, the separation could be reduced from a period of two hours to one of but a few minutes. By this reduction in the time of separation, an enormous saving in time and cost of manufacture was accomplished, and the research department received immediate recognition.

From the first beginning to the present time, progress in research has been like a triumphal procession. Investigations of existing manufacturing processes led to changes in the manufacture of nitro-glycerine, nitric acid, sulphuric acid, and ammonium nitrate, all of which are raw materials for the manufacture of dynamite, nitrocellulose and ether for smokeless powder manu-

facture, and acid and solvent recovery; they have enabled us to obtain practically theoretical chemical yields in the manufacture of these products; and by improvements in machinery, equipment, methods of handling and by substitution of mechanical processes for labor, they have accomplished savings of millions of pounds of raw materials and a corresponding monetary saving.

Without going into this matter in detail, I wish to mention several developments which have occurred since the beginning of the war, and which will contribute in no small measure to a final successful end of it.

In 1914, when the British embargo cut off the supply of German potash salts, the duPont Company was in a position to undertake the immediate production of potash salts from its nitrate deposits in Chile, as the research department had already discovered the presence of these salts in these deposits, and had worked up a satisfactory method for their extraction. This achievement not only assists in helping to meet the shortage of potash salts, but insures a supply for the manufacture of black ignition powder, which is absolutely necessary for igniting and firing charges of smokeless powder in our large guns.

A threatened shortage in the supply of sheet lead, and an actual shortage of lead burners and the necessity for a tremendous increase in the production of sulphuric acid for the manufacture of explosives made it imperative to find a substitute for lead in the construction of sulphuric acid plants. This problem was solved satisfactorily, and to-day millions of pounds of sulphuric acid are being manufactured in plants which have not a pound of lead in their construction.

The problems of the manufacture of diphenylamine, a necessary ingredient in smokeless powder which prevents its deterioration, and of the raw material, aniline, used in the manufacture of diphenylamine, were quickly and satisfactorily solved in American research laboratories; and this ingredient, which was obtainable in large quantities only from Germany, is now manufactured in this country, thousands of pounds per day.

While these developments and achievements illustrate what has been done in the way of supplying requirements, or furnishing substitutes for raw materials difficult or impossible to obtain, the accomplishments in the field of conservation of material have been as great, if not greater. Two might be mentioned here which, from the standpoint of magnitude, are well worth noting. In the manufacture of the type of powder employed by the United States Army, and now largely employed by the Allies in Europe, large quantities of alcohol and ether solvent are required. On account of the volatility of both of these substances, large losses take place during the manufacture of powder. By studying carefully these losses in the places where they occur, changes in manufacturing operations were made possible which enabled us to save solvent which, under the present scale of manufacturing powder, would amount to some fifty million pounds per year. Likewise, in the manufacture of gun cotton, where large quantities of nitric acid were lost several years ago, we have been enabled by careful study to make changes which have accomplished a saving equivalent to some forty-five million pounds of nitric acid a year. When it is remembered that heretofore nitric acid has been manufactured almost entirely from

Chile saltpetre, and that the scarcity of shipping has made it difficult to maintain an adequate supply of this material, which is so essential for the successful raising of large crops, it will be realized what the chemical research of this one company alone has been able to contribute to the successful termination of the war, aside, and in addition to, the production of actual military explosives.

Before the United States entered the war, the demand for toluol became so great, and the price so high, that two distinct methods for the synthetic manufacture of this material were developed. Two methods for the manufacture of picric acid were also developed and operated satisfactorily.

There is a high explosive used for primers in military explosives, as well as in blasting caps, known as tetryl, or tetranitromethylaniline. A process for the manufacture of tetryl or tetranitromethylaniline was developed and put in satisfactory operation, as well as the process for manufacturing dimethylaniline.

Because of the extensive program for the manufacture of high explosives planned after the United States entered the war, it became necessary to develop other high explosives than trinitrotoluol, picric acid and ammonium nitrate, and within a very short period the research department developed four new high explosive materials, all of which have been adopted by the Government, and will materially relieve the situation.

It is hardly necessary to call attention to the developments carried on by the research laboratories, of not only the duPont Company, but also of a great number of other concerns which have resulted in a very satisfactory solution of the dye situation in this country, so that in a short time we will be producing all the important dyes which we were of necessity importing from Germany before the war.

These instances from the experience of one company could be multiplied many times and the list of accomplishments of every large industrial corporation maintaining an adequate staff of research chemists could be greatly extended. As it is, I have only indicated the general trend toward an increased amount of research work as evidenced by the expansion which has taken place in the duPont Company, suggesting the possibilities in saving, in conservation of resources, and in increasing efficiency which can be accomplished by such a systematized and well organized research work.

The President has issued an executive order authorizing the Secretary of War to employ, without reference to the requirements of the civil service act, such persons in the research division, Chemical Warfare Service, at the American University, as may be needed in conducting certain investigations and construction work relating to gases and chemicals used in war, it being understood that all possible use will be made of the registers of eligibles of the Civil Service Commission. This authority shall continue only during the present war. The Commission concurs with the War Department in recommending this order because of the urgent and highly confidential character of the work involved and the fact that it must be organized and prosecuted with the greatest dispatch and be safeguarded most effectively.

## "Caliche" Beds Found to Be Small in Southeastern California

REPORTS were circulated in 1917 that large deposits of sodium nitrate were in Amargosa Valley, Ingo County, California. The Geological Survey has made an extensive search without finding verifications. In all, 78 trenches were dug, which had a total length of 3700 feet and an average depth of 2 feet 11 inches; 959 pits were dug to an average depth of 1 foot 7 inches; 1035 samples were taken, from which 930 analyses were made. In the so-called Upper Canyon field, at Acme Siding, 98 acres is estimated to contain 1430 short tons of sodium nitrate, but an overburden of about 100,000 tons would have to be removed in order to extract the caliche containing this nitrate. In the so-called Lower Canyon field 70 acres is estimated to contain 510 tons of sodium nitrate, the recovery of which would involve the removal of an overburden of about 50,000 tons. These two tracts are the largest and best of the ground examined, and, taken together, include 168 acres, which, if workable, might yield 1980 short tons of sodium nitrate, the recovery of which would involve the removal of 150,000 tons of overburden. The result of examinations at other places do not justify estimates of tonnage of nitrate.

The Survey's explorations have led to the following conclusions:

1. The nitrate in the Amargosa district occurs in a blanket of so-called "caliche," about 5 inches in average thickness, which lies about 9 inches below the surface of the ground. The nitrate is accompanied by other salts, chiefly sodium chloride.

2. The soil above and the bedrock below the deposits contain insignificant amounts of nitrate.

3. The high dip and the great thickness of the strata covered by the prospecting make it improbable that deeper beds of nitrate occur in this region.

4. The caliche in general contains an average of less than 2.5 per cent of sodium nitrate, the areal distribution of which is uneven.

5. The Zabriskie field, in which the newly found deposit was reported to lie, contains no commercially valuable nitrate.

6. The Upper Canyon and Lower Canyon fields, the most promising in the Amargosa district, together contain, according to careful estimate, about 168 acres of niter-bearing deposits, which, if worked regardless of cost, might produce about 1980 short tons of refined nitrate.

7. The quantity of nitrate available in the Amargosa district is so small and the cost of production would be so great that the district as a whole can not be regarded as a source of commercial nitrate.

8. No further work on the areas already examined is justified, except, perhaps, that in the nature of purely scientific research.

9. The occurrence of caliche nitrate deposits in the Amargosa district, rather than the usual cave or disseminated deposits, makes it seem possible, though improbable, that really valuable deposits of nitrate may occur elsewhere in the same general region.

10. Prospecting should be continued until all similar deposits in other districts have been tested sufficiently to determine their value.

## Aluminium and Its Light Alloys—II

The Technology of Casting, Hot and Cold Working—Production of Tubes and Foil—Composition of Fluxes and Solders—Effect of Mechanical Work and Heat Treatment on Physical Properties

By PAUL D. MERICA

### VII. TECHNOLOGY.

#### 1. CASTING

**P**RACTICALLY no aluminium is poured into sand or even chill castings today except for the production of rolling or melting ingots. "Aluminium" castings are made of an alloy of aluminium with copper, zinc or other metals; the subject of casting alloys of aluminium is discussed below.

For rolling and drawing aluminium is heated without flux in reverberatory or in crucible furnaces and poured into chill molds. Care is taken in melting to keep the temperature below 800°C; above this temperature the aluminium absorbs gas, oxidizes and a porous ingot may result. The melting is usually done at from 725 to 750°C. Quick cooling in the chill ingot molds is very necessary in order to secure a fine grain, and consequently good mechanical properties, as well as ease of hot rolling. When starting to pour a chill mold for rolling ingots the mold is held at an angle, such that the metal flows down one side and does not splash. During the pouring the mold is continually and slowly tilted in to the vertical position. In this manner cold sheets and similar flaws are prevented.

#### 2. WORKING

Sheet aluminium is usually rolled from one of the standard rolling ingots (see p. —). The ingots are reheated after casting to about 400°C and rolled down hot in from 10 to 12 passes to a sheet,  $\frac{1}{4}$  to  $\frac{3}{8}$  in. thick. This is then rolled cold to gage without intermediate annealing. Sheet as thin as 0.0005 in. may be rolled; this is of course foil. If soft sheet is desired the cold-rolled sheet is annealed, generally at from 375 to 400° C for 18 to 30 hours, and cooled in air.

Rods and wire are first hot rolled and then drawn cold to size, the methods differing but little from those in vogue for copper. Wire for example may be rolled hot from a square section billet weighing about 85 lb. (usually about 4 in. square in section and 5 or 6 ft. long), to from  $\frac{1}{2}$  to  $\frac{3}{8}$  in.; these rods are drawn cold to the wire sizes desired. Sometimes, particularly in European practice, all of the rolling is done cold instead. Tallow is used as a lubricant and the wire may be drawn at from 150 ft. (initial) to 600 ft. per minute final speed.

Tubes are made by the cupping of plates, followed by drawing on the press and then on the standard draw bench; this is done cold with intermediate annealing if necessary.

Sections, rods and tubes are also made by extrusion at higher temperatures, about 400°C, by hydraulic pressure. Sections up to 6 in. in diameter are made in this manner with wall thicknesses of as small as  $\frac{1}{4}$  in. Continuous tubing may be made also by this method.

Aluminium is very readily stamped, drawn and spun; cooking utensils and vessels of various kinds are produced by spinning annealed aluminium sheet. "In thicknesses above No. 20 B. & S. gage, aluminium will take a draw of from  $\frac{1}{4}$  to  $\frac{1}{2}$  more depth than will copper, brass or steel."

Aluminium foil, 0.0005 in. in thickness may be still further beaten into aluminium leaf almost as fine as gold leaf.

Pure aluminium is not readily machined; the metal drags, the tools do not cut but tear; files are "smeared" with the metal. The alloys of aluminium are much more readily machined; particularly the casting alloys. For the metal and its alloys the tool should be sharp with a good clearance, as for wood; the cut should be light and made under a suitable oil such as lard oil or the same mixed with 3 parts of benzine. A cutting speed somewhat greater than that used for brass is suitable.

#### 3. WELDING AND SOLDERING

Aluminium can be both soldered and welded, the latter by several different processes. In both cases a principal difficulty consists in the removal of the layer of oxide before the metal can flow together.

Aluminium may be welded by any of the different commercial processes. Aluminium sheet is generally welded by the oxy-acetylene or oxy-gas torch, the edges being butted for all but light gages, for which they are lapped or flanged. A flux should be used for sheet welding, and consists of a mixture in varying proportions of the chlorides and fluorides of sodium, potassium, lithium, aluminium and calcium. A few typical compositions of fluxes are given in table VI below. These fluxes should be finely powdered and before using moistened down with alcohol.

TABLE VI—PERCENTAGE COMPOSITION OF WELDING FLUXES  
(Pannell, 44, and others)

|   | Sodium<br>Chloride | Sodium<br>Fluoride | Sodium<br>Sul-<br>phate | Lithium<br>Chloride | Potassium<br>Chloride | Potassium<br>Fluoride | Potassium<br>Sul-<br>phate | Calcium<br>Chloride | Cryolite |
|---|--------------------|--------------------|-------------------------|---------------------|-----------------------|-----------------------|----------------------------|---------------------|----------|
| 1 | 30                 | ..                 | 3                       | 15                  | 45                    | 7                     | ..                         | ..                  | ..       |
| 2 | ..                 | 33                 | ..                      | 33                  | 33                    | ..                    | ..                         | ..                  | ..       |
| 3 | 12.5               | ..                 | ..                      | 30.8                | 62.5                  | ..                    | 4.0                        | ..                  | ..       |
| 4 | 16                 | ..                 | ..                      | ..                  | 79                    | ..                    | 5.0                        | ..                  | ..       |
| 5 | 17                 | ..                 | ..                      | ..                  | 83                    | ..                    | ..                         | ..                  | ..       |
| 6 | 6.5                | ..                 | 4.0                     | 23.5                | 56                    | ..                    | ..                         | ..                  | 10       |
| 7 | ..                 | ..                 | ..                      | ..                  | 60                    | ..                    | ..                         | 30                  | 6        |

The flame must not be held so close to the work as in steel welding, and a slightly reducing flame is to be used. A feeding stick of the same composition should be used; if the joint edges are flanged a feeding stick is not necessary.

Castings may be welded in the same manner, except that it is not necessary to use a flux, although results are generally better when it is used. The casting should be well supported so that no stress comes upon the welded joint while it is hot, as the metal is fragile and brittle at a temperature below the melting point.



In welding work on castings, the latter should preferably be pre-heated in order that internal stresses caused by shrinkage are not left in the welded casting when cool.

Arc welding may also be used for repair work on castings, but is not used for sheet and thin work.

Rods and wires are best butt welded by a combined heating and pressure method. The older methods of Heroult and of Cowper-Coles consisted in squaring off the ends of bars, heating these ends to about 400°C and bringing them together and hammering them (Heroult) or under pressure (Cowper-Coles). The electric resistance butt welding machines have however, furnished a much more suitable means of heating and applying pressure than the older processes and are in general use.

Spot-welding of sheet aluminium has been done but does not seem to give as reliable a joint as the oxy-acetylene process.

Welding, chiefly oxy-acetylene, is now quite widely practiced, both on aluminium castings and on sheet. Large numbers of welded aluminium vessels, pans, and containers of various sorts are manufactured each year. The welds are in most cases so perfect that the weld cannot be detected in the finished article. However, the welding of aluminium by any of the above methods is not easy, and requires experience. Welders familiar only with iron and steel work will generally make a complete failure of their first aluminium work.

Although welding is the only process to be recommended for joining aluminium when the joint must have strength and is exposed to the weather, it may in many instances be advisable to solder aluminium articles instead of welding them. The application of solder is easier, requires no especially skilled operator and the temperature of application is not so high as to cause buckling or distortion in the welded piece. On the other hand the metals used in such solders are all electro-negative to aluminium; a soldered joint is rapidly attacked by water or moisture, the joint becoming completely disintegrated in a short time. Only when the joint may be varnished or protected or for very heavy joints where slight corrosion would not be serious should solder be used.

It would be useless to give a list of all of the recommended solders for aluminium now on the market. They consist for the most part of varying mixtures of zinc, tin and aluminium of which Table VII will give some typical examples of those most generally used. Some

TABLE VII.—PERCENTAGE CHEMICAL COMPOSITION OF SOME ALUMINIUM SOLDER

| Reference                      | Zinc  | Tin   | Aluminium | Lead  | Copper | Cadmium           |
|--------------------------------|-------|-------|-----------|-------|--------|-------------------|
| Burgess & Ham-burgh (146)..... | 74    | 2     | 24        | ..... | .....  | .....             |
| Richards (256).....            | 63    | 31    | 3         | ..... | .....  | .....             |
| Auel (235).....                | 35    | 63    | 0.25      | ..... | .....  | Phosphor-tin—3    |
| Wust.....                      | 50    | ..... | 30        | ..... | 20     | .....             |
| Wust.....                      | 65    | ..... | 20        | ..... | 15     | .....             |
| Wust.....                      | 80    | ..... | 12        | ..... | 8      | .....             |
| Wust.....                      | 85    | ..... | 9         | ..... | .....  | Brass—6           |
| Wust.....                      | 88    | ..... | 7         | ..... | .....  | Brass—5           |
| Wust.....                      | 90    | ..... | 6         | ..... | .....  | Brass—4           |
| Wust.....                      | 94    | ..... | 4         | ..... | 2      | .....             |
| Bates (257a).....              | ..... | 30    | 70        | ..... | .....  | .....             |
| Bates.....                     | ..... | 80    | .....     | ..... | 10     | .....             |
| Bates.....                     | ..... | 20    | 70        | ..... | 10     | .....             |
| Stirling.....                  | 15.2  | 61.6  | 11.2      | 8.3   | 2.5    | Antimony—1.2      |
| Roesch.....                    | 50.2  | 48.6  | .....     | ..... | 0.2    | Antimony—0.7      |
| Bureau of Standards            |       |       |           |       |        |                   |
| Sn 1.....                      | 8     | 78    | 9         | ..... | .....  | 5 Phosphorus—0.25 |
| Sn 3.....                      | 9     | 86    | 5         | ..... | .....  | .....             |
| Sn 4.....                      | 9     | 86    | 5         | ..... | .....  | .....             |
| Zn 1.....                      | 75    | ..... | 5         | ..... | .....  | 20                |
| .....                          | 90    | ..... | 6         | ..... | 4      | .....             |

mixtures contain copper, lead, bismuth, antimony, and iron, the function of which is certainly not clear; in fact these metals are probably harmful.

Solder is best applied without a flux. The edges of the aluminium are filed clean and tinned with the solder, which should be thoroughly rubbed into the surface with a wire brush or with waste. The joint is then readily made in the usual manner between the tinned surfaces, using an iron if necessary.

#### 4. ELECTROLYTIC DEPOSITION

The deposition of aluminium from a bath of its fused salts has been noted above. The electrolytic separation of aluminium from its aqueous solutions can be effected but the current efficiency is very low and the metal not adherent; it is therefore never done commercially.

The electroplating of other metals on aluminium is of somewhat more importance but this operation is also attended with the greatest difficulty, due to the high chemical reactivity of the metal. The principal difficulties are (1) the thorough cleansing of the surface of the aluminium, and (2) the securing of an initial layer of electro deposited metal which is adherent; aluminium behaves in this respect in a manner much similar to iron.

There are a number of patents claiming the accomplishment of these two operations. The firm, Mix and Genest, have given a great deal of attention to this problem and describe in their patents a number of processes for the preparation of the metal for the plating bath. Some of them are:

- (1) The use of hot or cold sodium hydroxide (NaOH).
- (2) The use of halogen acids with the addition of alcohol, glycerine, etc.
- (3) The use of gelatine in a hot dilute alkaline bath (borax, sodium phosphate, etc.).
- (4) The use of glycerine with potassium carbonate, alkali phosphate, etc.

Canac and Tassilly (260) describe a long process depending on the cleaning of the aluminium with KOH or  $K_2CO_3$ , brushing with milk of lime, dipping in 2% KCN, dipping in a solution (A) of 500 gr. HCl, 500 gr. water, 1 gr. iron, followed by washings and repetition alternately of dipping in solution (A) and water until, as they claim, an adherent coating of iron has been produced upon the aluminium, upon which copper or any other metal must then be deposited in the usual manner.

The present processes for electro plating aluminium are not satisfactory; an adherent layer is not produced. Furthermore the electro deposition of metals upon aluminium as a measure of protection against corrosion is of most doubtful value, since a layer of all metals electronegative to it protects only mechanically, and actually by galvanic action accelerates corrosion, once the layer is pierced, whereas metals electropositive to aluminium are too readily corroded to effect any protection to it. Much better protection is afforded by a varnish or a paint (see above).

#### 5. MISCELLANEOUS

*Finish.* Aluminium is given several types of finish; the two most important are the polished and the satin finish. The former is obtained in the usual manner by buffing with rouge. The latter is obtained either:

(1) by caustic dipping; the metal is cleaned in benzene, dipped in boiling concentrated caustic soda, washed, dipped in hot, strong nitric acid, washed in boiling water and dried very quickly.

or (2) by scratch-brushing; the metal is carefully freed from grease and then brushed on the wire brush wheel.

**Granulating.** Granulated aluminium has been used in the manufacture of steel. It is made by pouring molten aluminium in thin streams into cold water, which is stirred. The metal may for this purpose be poured through a sieve.

**Calorizing.** Ruder (46) describes a process of coating metals with aluminium by heating in a mixture of aluminium and aluminium oxide at higher temperatures. This is accomplished at from 700° to 800° for copper and from 900 to 950° C for iron and steel. The layer formed varies from 0.025 per cent to 0.010 mm. in thickness.

Aluminium has been applied by the Schoop process.

Aluminium powder for painting and the thermite reaction is produced by rubbing foil through a metal sieve under molten fat.

## VII. THE PROPERTIES OF ALUMINIUM AS AFFECTED BY MECHANICAL WORK AND BY HEAT TREATMENT

When aluminium is cold worked the hardness or tensile strength is increased and the ductility or elongation in the tensile test decreased. The manner in which these properties vary with different amounts of cold working is shown in Figure 9, drawn from data

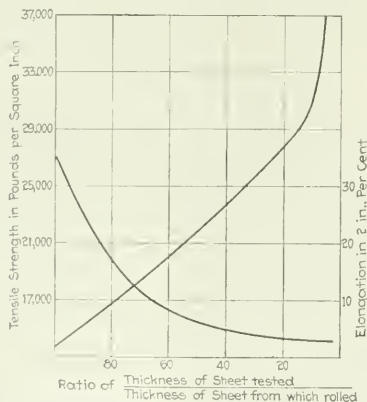


FIG. 9.—EFFECT OF COLD WORKING ON THE TENSILE PROPERTIES OF ALUMINIUM SHEET

kindly supplied by the Aluminum Company of America from tests on cold rolled sheet.

The Shore scleroscope hardness number (magnifying hammer) increases also from 5 to 6 for annealed aluminium sheet, to from 15 to 20 for hard sheet.

Annealing produces a recrystallization and softening of the metal. Only recently, Carpenter and Taverner (207) have made a systematic study of the rate of softening of aluminium sheet, by annealing at different temperatures. They used sheet cold rolled to 0.125 in. (probably from  $\frac{3}{8}$  inch, but the exact amount of cold reduction was not known to the authors), of four materials of the following average analysis: Silicon, 0.75

per cent (0.70 to 0.81); iron 0.34 (0.34 to 0.36); copper, 0.03.

A general idea of the results of their tests is gained from Figs. 10 and 11. The principal facts developed by this investigation are:

(1) The hardness caused by mechanical work is lost very rapidly upon annealing at from 300 to 500°C. The

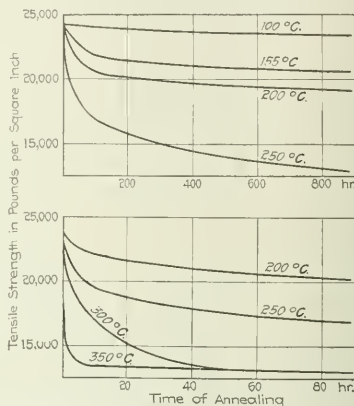


FIG. 10.—EFFECT OF ANNEALING ON TENSILE STRENGTH OF COLD-WORKED ALUMINIUM (CARPENTER AND TAVERNER)

same final tensile strength of about 12,700 lb. per sq. in. is obtained in all cases.

(2) The softening is most marked within the first portion of the annealing period.

(3) No hardening by annealing was noticed as in the case of copper and brass.

(4) Below 300°C. the decrease in hardness is very slow, but occurs within the temperature range of 100 to 200° with no increase of ductility.

The authors did not study the effect of previous cold reduction on the rate of softening by annealing, but

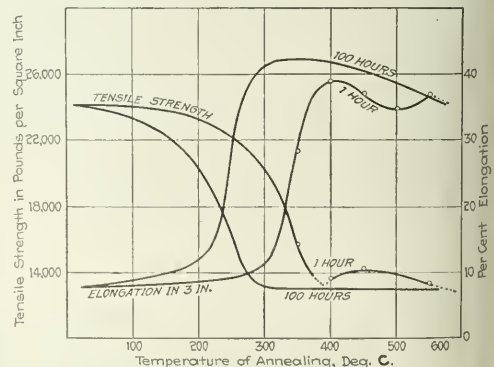


FIG. 11.—THE ANNEALING OF COLD-WORKED ALUMINIUM (CARPENTER AND TAVERNER)

there is no doubt but that the extent of this reduction has a great effect upon the annealing of the metal, as has been shown to be the case with copper.

Some annealing tests on aluminium tubes are described by Breuil (204).

(To be continued)

## The Deresination of Rubber—II

Description of a Plant for Producing About 400 Tons of Deresinated Guayule per Annum — Specific Gravity Tables for Solvents — Tables for Determining Mixed Solvents.

By ANDREW H. KING

THE deresinating plant of which Fig. 1 is a diagram, was a small one having a maximum capacity of about 400 tons of deresinated Guayule per year. It was housed in a two-story brick and steel building 50 feet wide by 150 feet long, and 32 feet high. Both floors were concrete, carefully sloped to drains placed at frequent intervals. The equipment consisted of two washers, two vacuum dryers, three churns, five kettles, six condensers, a recovery tower, pumps, and numerous tanks. On the first

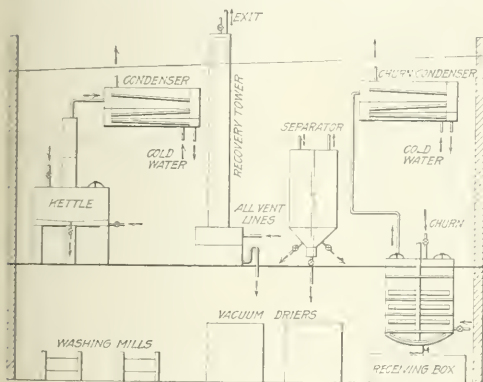


FIG. 1—DIAGRAM OF A DERESINATING PLANT

floor were the washing rolls and vacuum dryers. The churns were suspended from the second-story floor beams and projected only about a foot into the upper story. Underneath them were large receiving boxes. The rest of the first floor served for storage. Most of the apparatus was on the second floor, the kettles in a row on one side and the churns on the other. The condensers were suspended from the roof trusses. The recovery tower, into which all the condensers, churns, and separator were vented, was placed at one end of the room and the separator at the other. The pumps and most of the valves were situated in the middle of the room. On the roof a cooling device was installed for cooling condenser water. This consisted of many feet of pipe which was kept wet with water. Steam was supplied from the main power plant some distance away.

**Churns.** The churns were cylindrical in shape, with bulged bottoms. They were made of boiler iron  $\frac{3}{8}$  inches thick on the sides and  $\frac{1}{2}$  inch thick on the bottom and top. The capacity of each was about 2300 gallons. The internal measurements were 8 feet deep by 7 feet in diameter. The churn was charged through two iron doors 20 inches in diameter placed in the top, which, when closed, were pressed by screw clamps into special gaskets. Discharge was through a 16-inch gate valve

attached at the bottom. Four pairs of paddles mounted on a 3-inch shaft supplied the necessary agitation. The paddles were 40 inches, 58 inches, 76 inches and 106 inches respectively from the top. The bottom pair were curved so as to produce an upward current in the churn. There were three pairs of stationary paddles which also served to stay the shaft and keep it straight during operation. A 15-hp. motor supplied sufficient power for the three churns. The paddles could be rotated in either direction by means of a clutch. Liquids were pumped into the churn through a 6-inch line entering at the top. By teeing and suitable valves this line also served to carry vapors to the condenser during "steaming off" and to connect the churn with the vent system while treating rubber with the mixed solvent.

Following each treatment with mixed solvent a settling period was always allowed, during which the rubber settled to the bottom of the churn. The supernatant liquid was then pumped off by means of a rather ingenious device. A number of lengths of pipe were connected by swinging joints so that they might be straightened out to almost any desired length. To the end which went down in the tank a "J" shaped affair was attached, as in Fig. 2. The lower legs of the "J" were broad and had a mirror-like polish. The entrance was through an opening in its center. This hole was screened with fine wire, set in after the fashion of down spout guards. By holding an electric light overhead and carefully manipulating the pipes one could pump out the solvent right down to the layer of rubber.

**Kettles.** The kettles should rightly have been classed as pans since they were 8 feet in diameter and but 4 feet high. They were made of  $\frac{1}{2}$ -inch boiler iron and were steam jacketed only on the bottom. The jacket was built to withstand 200 pounds of steam pressure. Each kettle was supported by three brick pillars 12 inches square and 4 feet high. All pans were equipped with still heads. On four of them the head was 18 inches in diameter by 3 feet high. The other, which ran exclusively on acetone and water, had a head 18 inches in diameter by 7 feet high. There was an elliptical manhole, two feet by one foot, in the top of each kettle. Charging was accomplished through a 4-inch line entering at the top. The bottom of the still had a slight slant so that it would drain properly to the 4-inch line opening out at the deepest point. From the top of the still head a 4-inch line carried the vapors to the condenser. The maximum capacity of each kettle was

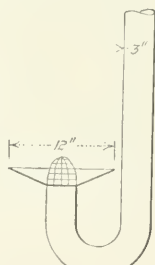


FIG. 2—"J" SHAPED SUCTION DEVICE



about 1400 gallons, but 1000 gallons was a safe charge. When working properly about 300 gallons of mixed solvent could be distilled per hour.

**Condensers.** The condensers were quite satisfactory when a sufficient supply of cold water was available. The shell of the condenser was 4 feet in diameter by 10 feet long. The pipes were 1 inch in diameter by 8 feet long and were of brass. They were arranged in three compartments and were suitably inclined so that liquid condensed in the first one would flow on through. The top section contained 130 tubes, the middle one 60, and the bottom one 40, making a total of 230 tubes. Vapor coming from the still entered the top section; part of it was condensed, and flowed by gravity into a compartment which connected with the middle section. After flowing through the middle section the liquid and uncondensed vapor entered another compartment from which it passed into the bottom section. Cold water was kept circulating around the tubes within the shell. Vapor entrance was effected through a 4-inch line; condensate exit was through a 3-inch line. Water lines were 3 inches in diameter. A vent pipe connected the lower section with the recovery tower, thus maintaining atmospheric pressure in the condenser.

The condensers did not work properly when the temperature of the cooling water rose above 17° C., so about 1000 feet of 2-inch pipe was arranged in coils on the roof, over which water was kept constantly spraying. Each kettle had its own condenser, while but one was required for the three churns.

**Separator.** For separating mixtures of acetone and water from acetone and gasoline an apparatus similar to an ordinary separatory funnel was employed. It consisted of a cylinder 5 feet in diameter by 8 feet in height, with a truncated cone 2 feet long at the bottom. The lower section of this cone was 1 foot in diameter. At this point a section of pipe 1 foot in diameter by 2 feet long was attached. Gage glasses were arranged so as to interlock, and one could follow the line of separation all the way from the top to the bottom. The separator was made of ½-inch boiler iron and was supported by means of brackets resting on

brick pillars. Charging was accomplished through a 4-inch pipe entering at the top. A vent pipe opening into the recovery tower was provided at the top. At the bottom were four different lines for carrying acetone-gasoline, gasoline, acetone and acetone-water to and from their respective tanks. The capacity of the separator was approximately 1000 gallons.

**Recovery Tower.** All churns, the condensers, and the separator had vent lines opening into the recovery tower, thus maintaining atmospheric pressure throughout. This apparatus consisted essentially of a 20-foot stack of boiler iron ½ inches thick, 2 feet in diameter, with a cylindrical receptacle at the bottom which measured internally 4 feet in diameter by 5 feet deep. The vent line (a 4-inch line) entered the column at the top of the lower receptacle. From the top of the stack a very fine spray of cold water was kept constantly falling. A 3-inch pipe opening from the top of the stack gave access to air. Discharge was through a 3-inch pipe opening a little above the bottom of the lower receptacle. A trap was placed in this line a short distance past the column. Gage glasses were provided for the lower receptacle only. The fine spray of water was particularly efficient in washing out uncondensed acetone.

**Fittings.** All pipe was made of extra heavy wrought iron with flange couplings. At necessary places sight boxes were provided, in which hydrometers were placed so that one could watch the flow of liquid and note the change in specific gravity. Three double-acting steam pumps furnished the necessary suction for the whole plant. There were ten large cylindrical tanks of 6000 gallons capacity each buried in the earth a short distance from the building.

**Solvent.** The solvent used for deresinating Guayule, Pontianack, Borneo, Palembang, etc., was composed by volume of 53 per cent acetone (98 per cent) and 47 per cent gasoline. The acetone used had a sp. gr. of .8041 at 15.5° C., and the gasoline was the grade known as 70 to 72° B., the specific gravity of which varies from .6981 to .7000. The grade in use at that time was obtained from Pennsylvania petroleum; practically all of it evaporated below 130° C. Spontaneous evaporation in the open air left no trace of that objectionable oil residue so prevalent now. Some data on the specific gravity of acetone and water mixtures are given in Table II. The percentages of gasoline

TABLE I

# RESIN CONTENT AND WASHING LOSS OF VARIOUS RUBBERS

|                                     | Botanical Origin                                    | Geographical Origin                            | Washing Loss Per Cent | Resin Content, based on Washed and Dried Rubber |
|-------------------------------------|-----------------------------------------------------|------------------------------------------------|-----------------------|-------------------------------------------------|
| Plantation Crepe...                 | Hevea brasiliensis.....                             | Ceylon and Fed. Malay States.....              | 2-1                   | 3-3.6                                           |
| Plantation Scrap...                 | Hevea brasiliensis.....                             | Ceylon and Fed. Malay States.....              | 8-12                  | 2.5-4.5                                         |
| Islands Fine Para (Soft Cure)....   | Hevea brasiliensis.....                             | South America, Islands Lower Amazon.....       | 17-20                 | 2-3                                             |
| Fine Para, Up-river (Hard Cure).... | Hevea brasiliensis.....                             | Upper Amazon Valley.....                       | 14-19                 | 1.6-3                                           |
| Caucho Balls....                    | Hevea brasiliensis and other Hevea species.....     | Amazon Dist. and its southern tributaries..... | 18-30                 | 3.5-5.5                                         |
| Sumatra.....                        | Ficus elastica.....                                 | Sumatra.....                                   | 10-25                 | 7-15                                            |
| Islands Coarse....                  | Para Sapim tabura.....                              | Lower Amazon and Islands.....                  | 20-40                 | 2-6                                             |
| Java.....                           | Ficus elastica.....                                 | Java.....                                      | 10-30                 | 3.7-8.5                                         |
| Ceara.....                          | Manihot Glaziovii and other Manihot species.....    | Province Ceara.....                            | 25-46                 | 2.5-4                                           |
| Manicoba.....                       | Species of Manihot.....                             | Grande de Norte.....                           | 30-55                 | 3-6.5                                           |
| Cameroon Balls....                  | Funtumia elastica and Landolphia ovariensis.....    | Africa, Cameroon.....                          | 26-45                 | 10-20                                           |
| Palembang.....                      | Dyera costulata.....                                | Sumatra.....                                   | 64-70                 | 70-85                                           |
| Borneo, Pontianak, Jelutong.....    | Dyera costulata, chiefly Parthenium argentatum..... | Borneo..... Mexico.....                        | 64-70                 | 70-85                                           |
| Guayule.....                        | Parthenium argentatum.....                          | Mexico.....                                    | 15-40                 | 23-26                                           |

TABLE II.

# Acetone and Water

|                                                                                   |        |
|-----------------------------------------------------------------------------------|--------|
| Pure Acetone 100 per cent has a Sp.Gr. of 0.795 at 15.5° C. and boils at 56.5° F. |        |
| Mixtures of acetone and water at 15.5° C.                                         |        |
| 100% pure acetone has a sp.gr. of.....                                            | 0.795  |
| 99 pure acetone, 1% water, has a sp.gr. of.....                                   | 0.7995 |
| 98 pure acetone, 2 water, has a sp.gr. of.....                                    | 0.8041 |
| 97 pure acetone, 3 water, has a sp.gr. of.....                                    | 0.8084 |
| 96 pure acetone, 4 water, has a sp.gr. of.....                                    | 0.8125 |
| 95 pure acetone, 5 water, has a sp.gr. of.....                                    | 0.8164 |
| 94 pure acetone, 6 water, has a sp.gr. of.....                                    | 0.8201 |
| 93 pure acetone, 7 water, has a sp.gr. of.....                                    | 0.8237 |
| 92 pure acetone, 8 water, has a sp.gr. of.....                                    | 0.8272 |
| 91 pure acetone, 9 water, has a sp.gr. of.....                                    | 0.8306 |
| 90 pure acetone, 10 water, has a sp.gr. of.....                                   | 0.834  |

and acetone given above mix perfectly. The specific gravity of the mixed solvent is .755. Table III contains corrections for specific gravity of acetone at different temperatures.

**Method of Operation.** Churns of the size described above require a charge of 1200 pounds of Guayule or 5000 pounds of Ponti. The necessary amount of rubber

is weighed up, then put through the cold washing rolls. With Guayule, no attempt to sheet was made, and no water was used. The rubber was only coarsely broken down. With Ponti, water was employed and the pieces allowed to drain off as much as possible before charging. The partly broken down Guayule was taken to the charging floor, the churn was made ready by closing the 16-inch valve in the bottom, opening the valve to the vent line and by closing all steam lines. The churn was then pumped one-fourth full of the mixed gasoline and acetone solvent, previously adjusted to the correct proportions. Then the paddles were started and the charge dropped in, after which the churn was filled within 6 inches of the top with solvent. The manholes were closed and the churn left running on the first treatment which lasted 2 hours, when it

TABLE III.  
Tests for Acetone

Boiling Point 56-57° C.  
131° F.

Sp.Gr. 1797

Sp.Gr. Acetone and Water Mixtures at 15.5° C.

|          |        |
|----------|--------|
| 90% pure | 0.834  |
| 91 pure  | 0.8306 |
| 92 pure  | 0.8272 |
| 93 pure  | 0.8237 |
| 94 pure  | 0.8201 |
| 95 pure  | 0.8164 |
| 96 pure  | 0.8125 |
| 97 pure  | 0.8084 |
| 98 pure  | 0.8041 |
| 99 pure  | 0.7995 |
| 100 pure | 0.7946 |

Coefficient of Exp. = 0.0011

Corrections for Acetone for Sp.Gr. at Different Temperatures

| Deg. C. | Deg. C. | + |
|---------|---------|---|
| 0.0055  | 10.0    |   |
| 0.0049  | 10.6    |   |
| 0.0044  | 11.1    |   |
| 0.0038  | 11.7    |   |
| 0.0033  | 12.2    |   |
| 0.0027  | 12.8    |   |
| 0.0022  | 13.3    |   |
| 0.0016  | 13.9    |   |
| 0.0011  | 14.4    |   |
| 0.0005  | 15.0    |   |
| 0.0004  | 15.6    |   |

Add to Sp.Gr. over 15.5° C.

|      |        |
|------|--------|
| 16.1 | 0.0006 |
| 16.7 | 0.0012 |
| 17.2 | 0.0017 |
| 17.8 | 0.0023 |
| 18.3 | 0.0028 |
| 18.9 | 0.0034 |
| 19.4 | 0.0039 |
| 20.0 | 0.0045 |
| 20.6 | 0.0051 |
| 21.1 | 0.0056 |
| 21.7 | 0.0062 |
| 22.2 | 0.0067 |
| 22.8 | 0.0073 |
| 23.3 | 0.0078 |
| 23.9 | 0.0084 |
| 24.4 | 0.0089 |
| 25.0 | 0.0095 |
| 25.6 | 0.0101 |
| 26.1 | 0.0106 |
| 26.7 | 0.0112 |
| 27.2 | 0.0117 |
| 27.8 | 0.0123 |
| 28.3 | 0.0128 |

Subtract from Sp.Gr. below 15.5° C.

steam line opened. "Steaming off," as it was called, was continued until nothing but water or water with a thin film of oil appeared at the sight box, at which time the hydrometer reading rose to 1000. When this occurred, the charge was ready to be dropped. The large valve at the bottom was opened, the paddles reversed, and a stream of water played on the rubber through the manhole. The charge fell into a large zinc-lined box placed underneath the churn. After cooling sufficiently the rubber was taken out, washed with water on the washing rolls, and sheeted. Drying was accomplished by means of a vacuum dryer.

The schedule of treating was as follows:

|                  |            |
|------------------|------------|
| First treatment  | 2 hr.      |
| Settle           | ½ hr.      |
| Pump Off         |            |
| Second treatment | 1 hr.      |
| Settle           | ½ hr.      |
| Pump Off         |            |
| Third treatment  | 1 or ½ hr. |
| Settle           | ¼ hr.      |
| Pump Off         |            |
| Fourth treatment | 1 or ½ hr. |
| Settle           | ¼ hr.      |
| Pump Off         |            |
| Steaming         | 4 to 5 hr. |

The actual time per cycle was about 10 to 14 hours, because of the time required for pumping out the respective charges and for discharging. About four charges were handled with the three churns running the full 24 hours. Fig. 3 is a diagram of the operation of the process described above.

With 1200 pounds of Guayule as a charge, the mixed solvent required for the first treatment was 1800 gal-

was stopped and the rubber allowed ½ hour to settle. The "J" shaped pipe was screwed into the suction line and the resin-laden solvent pumped into the acetone-gasoline-resin tank, where it remained until ready to purify. The churn was again filled with solvent and run for 1 hour, settled ½ hour, and pumped out as before into the acetone-gasoline-resin tank. The rubber was given two more treatments of either 1- or ½-hour duration with 15-minute settling periods between. The first and second treatments removed most of the resin. The third and fourth were largely diluting and purifying treatments and carried but little resin, so this solvent was used over again in the first and second treatments of the next charge.

After four lots of solvent had been pumped out, water was added in order to precipitate the rubber, and matt it together. The vent line was closed and the

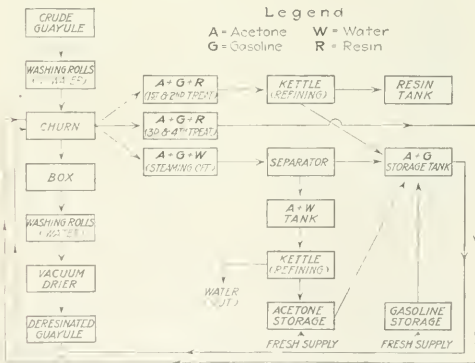


FIG. 3—CYCLE OF OPERATIONS

lons, and for all others about 1400 gallons, making about 13,000 gallons mixed solvent required per day. The solvent losses did not usually run over 44 gallons of gasoline and 15 gallons of acetone per 1000 pounds of rubber produced. With Guayule the yield of dry rubber was seldom more than 55 per cent of the weight of the charge. This was because the rubber was not washed and dried before deresinating. It was found more satisfactory to merely mill the gum until it was partly broken down and dry it by means of solvents.

The high washing loss of Guayule, about 20 per cent. was also a factor. The maximum daily output of deresinated rubber was about 2600 pounds.

In view of the large quantities of liquids required it is obvious that much depended upon the skill with which the plant superintendent refined his solvents. If he grew careless, he might lose enough to completely wipe out the profits. The liquor from the first and second treatments was pumped with the dissolved resin to the proper tank. From here it went to a kettle where the gasoline and acetone were distilled off and the condensate piped to its tank. The resin of Guayule, being fluid, was also pumped to a tank. The liquor from the third and fourth treatments, being fairly pure, was used in the first and second treatments on the next charge. The condensate from the steaming-off operation consists of gasoline, water, and acetone. This mixture was pumped to the separator and allowed to come to equilibrium. The top layer consisted of gasoline and acetone and the lower of acetone and water. The quantity of acetone in the gasoline depended upon the amount of water present. The acetone and water, and acetone and gasoline were carefully drawn off and piped to a separate container.

No attempt was made to separate the acetone from the gasoline in the acetone-gasoline mixture. This cannot be done by distillation since they form a minimum boiling point mixture. It can only be accomplished by adding sufficient water and allowing the gasoline to rise to the top. Separation of acetone from gasoline was unnecessary since it was much simpler to add either acetone or gasoline to bring the mixture to the correct proportions. The acetone-water mixture was fractionated in the kettle with the tall still head, which was kept running entirely on this work. The acetone thus obtained was piped into the acetone storage tank and was drawn upon for balancing the solution to the proper concentration. Whenever gasoline was required it was supplied from storage tank.

The resin-laden solvent from the first and second treatments on distillation always gave a mixed solvent of about the proper concentration. Very little adjustment was ever required. But the acetone-water and acetone-gasoline condensate from the steaming-off operation was a different matter. The water removed acetone from the gasoline, thus making the top layer rich in gasoline and poor in acetone. The acetone content was determined by an indirect method, which arrived at the gasoline content first and that of acetone by difference. A 10-cc. sample of mixed solvent was drawn from the separator and placed in a 15-cc. graduated tube, which was filled to the 15-cc. mark with water and the tube well shaken. It was then placed in an ordinary urine analysis centrifuge and whirled about a minute. The acetone-water solution was removed from the bottom of the tube by a pipette. This was repeated once more. Ten cc. of water were then added, mixed, and whirled again. The reading above the 10-cc. mark, that is the gasoline layer, readily gave the gasoline content. The percentage of acetone was obtained by difference. In order to make use of this mixed solvent, one had only to solve a simple algebraic problem: Given a certain volume of mixed solvent  $V$  consisting solely of acetone and gasoline; let the percentage (by volume) of acetone in the mixture

be  $a$  which is determined; required (case 1) the quantity  $x$  (in gallons) of acetone to be added when the mixture contains less than 53 per cent acetone and (case 2) the quantity  $y$  of gasoline required when the acetone content is greater than 53 per cent.

$$\begin{array}{l} \text{Case 1.} \\ aV - x = \frac{.53(V - x)}{V} \\ .47x = \frac{.53V - .53x}{V(.53 - a)} \\ x = \frac{.47}{.53 - a} \end{array} \quad \begin{array}{l} \text{Case 2.} \\ (1-a)V + V = \frac{.47(V + y)}{V} \\ .53y = \frac{.47V + .47y}{V - .53} \\ y = \frac{.53}{.53 - a} \end{array}$$

Obviously the shift foreman of a deresinating plant could not stop to work out each separate problem, so his requirements were estimated beforehand and the quantities are recorded in Table IV.

The successful operation of a deresinating plant calls for eternal vigilance on the part not only of the foremen and superintendent but of every one concerned. All lines, tanks, kettles, condensers, etc., should be plainly numbered and a chart framed in a convenient place where the operation going on in any one is clearly indicated. All valves should have "open" and "closed" signs, and the purpose of each one clearly indicated by a tag wired to the wheel. A good rule is to keep all valves closed when not in use. The operation as above outlined is far from foolproof and a careless man can destroy a month's profit by one thoughtless act. Leaks of all kinds are to be very carefully watched for. The solvent loss is plenty high enough under the best of conditions without being increased by leaks. The greatest foe of successful operation is carelessness, of which the following is an example. A certain plant did not show a profit over a whole year, notwithstanding the fact that it was running at maximum capacity and apparently as efficiently as possible. Upon investigation it was found that through a mistaken idea on the part of a laborer they were sending about 1000 gallons of acetone each month into the sewer.

TABLE IV.  
Gallons Mixed Solvent

| Per Cent Acetone | Gallons | 30                      | 100 | 150 | 200 | 250 | 300 | 350 | 400 | 450 | 500 | 550 | 600 | 650 | 700 | 750 | 800 |
|------------------|---------|-------------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
|                  |         | Gallons Acetone to Add  |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| 30               | 49      | 73                      | 98  | 122 | 147 | 171 | 195 | 220 | 244 | 269 | 293 | 317 | 342 | 366 | 391 |     |     |
| 31               | 47      | 70                      | 94  | 117 | 140 | 164 | 187 | 211 | 234 | 258 | 281 | 304 | 328 | 352 | 376 |     |     |
| 32               | 45      | 67                      | 90  | 112 | 134 | 156 | 178 | 201 | 223 | 245 | 268 | 290 | 312 | 335 | 357 |     |     |
| 33               | 43      | 64                      | 85  | 106 | 128 | 149 | 170 | 192 | 213 | 234 | 256 | 277 | 300 | 321 | 342 |     |     |
| 34               | 40      | 61                      | 81  | 101 | 121 | 141 | 162 | 182 | 202 | 222 | 242 | 263 | 283 | 303 | 323 |     |     |
| 35               | 38      | 58                      | 77  | 96  | 115 | 134 | 154 | 173 | 192 | 211 | 230 | 250 | 269 | 288 | 307 |     |     |
| 36               | 36      | 54                      | 70  | 91  | 108 | 127 | 145 | 163 | 181 | 199 | 217 | 235 | 253 | 272 | 290 |     |     |
| 37               | 34      | 51                      | 68  | 85  | 102 | 119 | 136 | 153 | 170 | 187 | 204 | 221 | 238 | 255 | 272 |     |     |
| 38               | 32      | 48                      | 64  | 80  | 96  | 111 | 127 | 143 | 159 | 175 | 191 | 207 | 223 | 238 | 255 |     |     |
| 39               | 30      | 45                      | 59  | 74  | 89  | 104 | 119 | 133 | 148 | 163 | 178 | 193 | 208 | 223 | 237 |     |     |
| 40               | 28      | 41                      | 55  | 69  | 83  | 97  | 110 | 124 | 138 | 152 | 166 | 179 | 193 | 206 | 220 |     |     |
| 41               | 26      | 39                      | 52  | 66  | 79  | 92  | 105 | 118 | 131 | 144 | 157 | 170 | 183 | 197 | 210 |     |     |
| 42               | 24      | 36                      | 49  | 61  | 73  | 85  | 98  | 110 | 122 | 134 | 146 | 158 | 170 | 182 | 194 |     |     |
| 43               | 21      | 32                      | 44  | 55  | 64  | 74  | 85  | 95  | 106 | 117 | 127 | 138 | 148 | 159 | 170 |     |     |
| 44               | 19      | 29                      | 38  | 48  | 57  | 67  | 76  | 86  | 95  | 105 | 114 | 124 | 133 | 143 | 152 |     |     |
| 45               | 17      | 26                      | 34  | 43  | 51  | 60  | 68  | 77  | 85  | 94  | 102 | 111 | 119 | 128 | 136 |     |     |
| 46               | 15      | 22                      | 30  | 37  | 45  | 53  | 61  | 69  | 77  | 85  | 92  | 100 | 108 | 116 | 124 |     |     |
| 47               | 13      | 19                      | 25  | 32  | 38  | 44  | 51  | 57  | 63  | 69  | 76  | 82  | 89  | 96  | 101 |     |     |
| 48               | 11      | 16                      | 21  | 27  | 32  | 37  | 42  | 48  | 53  | 58  | 64  | 69  | 74  | 80  | 85  |     |     |
| 49               | 9       | 13                      | 17  | 21  | 26  | 30  | 34  | 39  | 43  | 47  | 52  | 56  | 60  | 64  | 69  |     |     |
| 50               | 7       | 10                      | 14  | 18  | 21  | 25  | 28  | 31  | 35  | 38  | 42  | 46  | 49  | 53  | 56  |     |     |
| 51               | 4       | 7                       | 9   | 11  | 13  | 15  | 18  | 20  | 21  | 23  | 26  | 28  | 30  | 32  | 34  |     |     |
| 52               | 2       | 3                       | 4   | 5   | 7   | 8   | 9   | 10  | 11  | 12  | 13  | 14  | 15  | 16  | 18  |     |     |
| 53               | 0       | 0                       | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   |     |     |
|                  |         | Gallons Gasoline to Add |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| 54               | 2       | 3                       | 4   | 5   | 5   | 6   | 7   | 7   | 9   | 10  | 11  | 12  | 13  | 14  | 14  |     |     |
| 55               | 4       | 6                       | 8   | 10  | 11  | 13  | 15  | 17  | 19  | 21  | 23  | 25  | 27  | 29  | 30  |     |     |
| 56               | 6       | 8                       | 11  | 14  | 17  | 20  | 22  | 25  | 28  | 31  | 34  | 36  | 39  | 42  | 45  |     |     |
| 57               | 8       | 11                      | 15  | 19  | 23  | 27  | 30  | 34  | 38  | 42  | 46  | 48  | 51  | 55  | 60  |     |     |
| 58               | 9       | 14                      | 19  | 24  | 28  | 33  | 38  | 42  | 47  | 52  | 56  | 61  | 66  | 71  | 76  |     |     |
| 59               | 11      | 17                      | 23  | 28  | 34  | 40  | 46  | 51  | 57  | 63  | 68  | 74  | 80  | 85  | 91  |     |     |
| 60               | 13      | 20                      | 26  | 33  | 40  | 46  | 53  | 59  | 66  | 73  | 79  | 86  | 92  | 99  | 106 |     |     |
| 61               | 15      | 23                      | 30  | 38  | 45  | 53  | 60  | 68  | 75  | 83  | 90  | 98  | 105 | 113 | 120 |     |     |
| 62               | 17      | 26                      | 34  | 42  | 52  | 60  | 68  | 77  | 85  | 94  | 102 | 111 | 119 | 128 | 136 |     |     |
| 63               | 19      | 28                      | 37  | 47  | 57  | 66  | 75  | 85  | 94  | 104 | 114 | 123 | 133 | 143 | 152 |     |     |
| 64               | 21      | 31                      | 42  | 52  | 62  | 73  | 83  | 94  | 104 | 114 | 125 | 135 | 146 | 156 | 166 |     |     |
| 65               | 23      | 34                      | 45  | 57  | 68  | 79  | 90  | 102 | 115 | 124 | 136 | 147 | 158 | 170 | 181 |     |     |
| 66               | 25      | 37                      | 49  | 61  | 74  | 86  | 98  | 111 | 125 | 135 | 148 | 160 | 172 | 184 | 197 |     |     |
| 67               | 26      | 40                      | 53  | 66  | 79  | 92  | 106 | 121 | 133 | 145 | 158 | 171 | 185 | 198 | 211 |     |     |
| 68               | 28      | 42                      | 56  | 71  | 85  | 99  | 113 | 127 | 141 | 155 | 169 | 183 | 197 | 212 | 226 |     |     |
| 69               | 30      | 45                      | 60  | 75  | 90  | 105 | 120 | 135 | 150 | 165 | 180 | 195 | 210 | 225 | 240 |     |     |
| 70               | 32      | 48                      | 64  | 80  | 96  | 112 | 128 | 144 | 160 | 176 | 192 | 208 | 224 | 240 | 256 |     |     |



## IMPROVEMENTS

**Churns.** These were about as efficient as can be expected of any intermittent process. Personally, I prefer continuous counter-current extraction, pumping the solvent from churn to churn. During steaming off there was a tendency for rubber to be carried into the condenser. Later this was prevented by installing a trap. Steaming off was not entirely a harmless operation. The heating brought about more or less depolymerization of the rubber, but at that time it was necessary in order to remove all the solvent. Vacuum distillation at a low temperature would give a much better product without the trouble of foaming.

**Kettles.** The kettles would have been more efficient if they had been steam jacketed around the sides. There was often a tendency to foam, which was particularly noticeable with Palembang. The use here of one of the modern kettles would greatly aid the efficiency of the plant. A vacuum kettle might help.

**Condensers.** The condensers functioned fairly well as long as there was plenty of cold water. The acetone still should have had a larger condenser, since there was hardly enough cooling surface to condense all the vapor when the still was working at maximum capacity.

**Recovery Tower.** The recovery tower was really a make-shift intended to catch uncondensed acetone, which unfortunately was no small amount. Its efficiency would be improved by filling the tower with any standard tower packing, thus increasing the surface.

**Separator.** Instead of the gravity separator described above, a centrifuge could be used to advantage.

Any chemical engineer can now suggest a number of sensible improvements. Deresinating practice will likely be almost entirely revised in the next few years.

## USES OF RESINS

Because of the scarcity of Ponti and related rubbers, their treatment was not given any particular discussion above. However, Ponti resin has certain uses. Being unsaponifiable it makes an ideal varnish for concrete. Pontiniack rubber and resin have been used in chewing gum. The products formed by dry distilling the resin are useful as a rubber substitute in cheap stocks.

Guayule resin is hard to dispose of, but is of value when added in small amounts to cheap stocks containing dry shoddies where its effect is that of a softener.

## CONCLUSION

The purpose of the writer in preparing this paper has been to set forth something of our knowledge of rubber resins and to revive interest in deresinating, which is now almost a lost art. In view of our efforts in the war the deresination of Guayule will no doubt be resumed within a short time.

Current prices in platinum are no indication of its former value. At one time the crude grains mixed in with the ore of certain gold mines in Colombia, South America, were regarded as a waste product and thrown away. The extent of recovery of this metal may be store, recovering enough platinum to enable him to be instanced by the case of one man who tore down his rebuild on a larger scale, and clear \$4,000 in American gold besides.

## Regulations Governing the Sale and Exportation of Caustic Soda

The U. S. War Industries Board and the War Trade Board jointly announce that on and after August 1, 1918, manufacturers of caustic soda in the United States will not enter into any contract for the sale of caustic soda with any person in the United States for the purpose of exporting the same, unless and until advised by the prospective purchaser that a United States export license covering such caustic soda has been duly obtained and the number thereof is furnished.

Manufacturers will not sell on and after the above mentioned date, caustic soda for domestic consumption unless the purchaser agrees not to export same nor to sell same for export, and if it is resold in the domestic market, to exact or cause to be exacted a similar agreement from each and every subsequent purchaser.

On and after August 1, 1918 the War Trade Board will not license for exportation caustic soda to any destination until the applicant complies with regulations contained in Ruling 175, copies of which can be obtained on application to any branch office of the War Trade Board.

## Patent Office Needs Technically Trained Persons

The Commissioner of Patents, Washington, D. C., announces the need of technically trained persons for the examining corps of the Patent Office. Men or women are desired who have a scientific education, particularly in higher mathematics, chemistry, physics, and French or German, and who are not subject to the draft for military service. Engineering or teaching experience in addition to the above is valued. The entrance salary is \$1500.

Examinations for the position of assistant examiner are held frequently by the Civil Service Commission at many points in the United States. One is announced for Aug. 21 and 22, 1918. Details of the examination, places of holding the same, etc., may be had upon application to the Civil Service Commission, Washington, D. C., or to the patent office.

Should the necessity therefor arise temporary appointments of qualified persons may be made pending their taking the Civil Service examination. Application for such appointment should be made to this office.

## Combustion Engineers Wanted

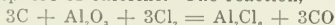
The Bureau of Oil Conservation, Oil Division, U. S. Fuel Administration, desires to secure a combustion engineer for each of the districts named below, who will act as inspector of all plants within the district using fuel oil and natural gas: Boston, Providence, New York City, Philadelphia, Pittsburgh, Buffalo, Detroit, Chicago, Minneapolis, Tulsa, New Orleans and San Francisco. It is desired that these men shall act as volunteers. The Administration will pay a reasonable compensation for men who cannot give their services for nothing. Only those who have had experience in the combustion of fuel oil and natural gas would be of value to the Administration. Application can be made to W. Champlain Robinson, Director of Oil Conservation, Oil Division, United States Fuel Administration, Washington, D. C.

## Recent Chemical and Metallurgical Patents

**Manganese Dioxide Depolarizer.**—In the preparation of a depolarizer with good electrical conducting qualities suited for use in dry batteries, MESSRS. CARLETON ELLIS and ALFRED A. WELLS of Montclair, N. J. (assignee, National Carbon Co.) patent the process of oxidation of manganese sulphate or chloride with hypochlorite in weak acid solutions at boiling temperatures. In strongly acid solutions, very little precipitate is obtained and in alkaline, the manganese is precipitated as brown manganic hydroxide and thus rendered unreactive with the free oxygen of the hypochlorite. When the sulphates are used, an excess of acid soon accumulates, which retards the reaction in proportion to its concentration; this excess acid is neutralized with sodium carbonate or basic manganese salts. In the case of the chloride salts, hydrochloric acid is volatilized to such an extent that either some of it must be condensed and returned to the solution or a slight amount of sulphuric acid or manganese sulphate must be added to maintain permanent acidity. With from  $\frac{1}{4}$  to  $\frac{1}{2}$  per cent acid content, a quantitative yield is claimed with a mixture of 10 volumes of 44 per cent manganese chloride, 25 volumes of 30 per cent sodium hypochlorite, 11 volumes of 10 per cent hydrochloric acid, and 9 volumes of water. (1,269,914, 1,269,915; June 18, 1918.)

**Aluminium Chloride.**—The price of aluminium chloride has been relatively high due to difficulties in getting suitable materials for furnace construction resistant both to high temperatures, carbon and chlorine. On this account, it has been more economical to burn high priced metallic aluminium in chlorine gas than to use a crude source of material such as bauxite.

MESSRS. GEORGE H. KING and GERALD I. ROBERTS of Port Arthur, Texas (assignee, Gulf Refining Company) patent the process of passing a finely ground mixture of carbon and alumina, which has been heated to a very high temperature in a separate furnace, through an atmosphere of chlorine. The reaction,



takes place with a maximum surface of reaction; dust impurities are removed mechanically before the aluminium chloride has condensed. Spent oil catalyst can be regenerated by this process, the product being oiled with kerosene to prevent hydrolysis with atmospheric moisture during the grinding process. (1,268,015; May 28, 1918.)

MESSRS. DILLON F. SMITH and HARRY ESSEX of Pittsburgh, Pa. (assignee, Gulf Refining Co.), patent the reaction between aluminium carbide, sulphide, etc., and chlorine or hydrochloric acid, which they state takes place as low as 200 deg. C. in an iron retort, the walls of which should be kept sufficiently cool to prevent the chlorine from reacting with the iron. (1,270,226; June 18, 1918.)

**Silica Fuse Filler.**—For the manufacture of a silica powder of low apparent gravity, weighing from 12 to 30 pounds per cubic foot, MESSRS. W. C. ARSEM and J.

G. E. WRIGHT of Schenectady, N. Y. (assignee, General Electric Company), patent the process of adding one part of 1.45 sp.gr. water glass to three parts of water and mixing with a solution of one part of ammonia chloride in eight parts of water, whereupon colloidal silica is precipitated in a very fine state having the approximate composition of  $SiO_2 \cdot NH_3 \cdot H_2O$ . The ammonia and water are removed from this precipitate by prolonged boiling and calcination of the filtered and washed hydrated silica.

**Manufacture of Ammonium Phosphates.**—INGENUIN HECHENBLEICKNER of Charlotte, North Carolina, has discovered that for the production of mono and di-ammonium phosphate the best concentration of phosphoric acid is from 35 to 43 per cent  $P_2O_5$ , the actual optimum varying with the purity of the acid and the heat insulation and the size of the apparatus. Fig. 4 shows this acid in tank 1, from whence it is distributed and trickles down the filling of tower 4, there absorbing a counter current of hot ammonia gas entering the system at 16. The resulting phosphate is further warmed by the considerable heat evolution of the reaction, and trickles through pipe 5 into the tube 7. Any remaining acid is neutralized by the ex-

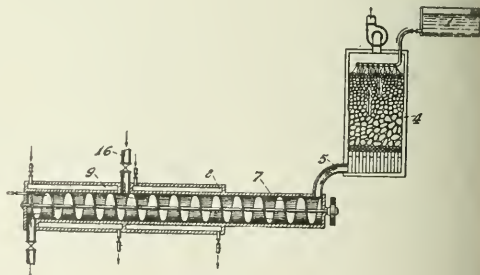


FIG. 1.

cess ammonia at this point, and crystallization starts immediately. The mixture is further dried by the steam jackets 8 and 9. The result is that in one continuous operation the inventor is enabled to produce mono and di-ammonium phosphate of a fine, dry, crystalline nature, stable and non-hygroscopic. In some cases the crystallizing tube may be replaced by a tank of water where the salts crystallize and are removed from time to time, centrifuged and steam dried if necessary. When di-ammonium phosphate is to be produced the solution in the saturation tank should be saturated hot until it has a slight ammonia odor. Di-ammonium phosphate is less soluble in hot water than in cold water and furthermore hot precipitation prevents the formation of tri-ammonium phosphate and gives a continuous crystallization of pure di-ammonium phosphate producing a fine, crystallized, stable, non-hygroscopic product. (Assigned to Southern Electro-Chemical Co., 1,264,513 and 14, Apr. 30, 1918.)

**Operation and repair of Kjellin Refining Furnace.**—DAVID R. KNAPP, of Pottsville, Pa., patents a device whereby the ordinary Kjellin furnace is placed on a circular plate capable of receiving a slight tilt, and

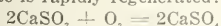
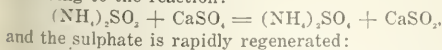
being slowly rotated simultaneously. In operation, the furnace is kept on a level keel at a normal temperature for the elimination of silicon and phosphorous. When these impurities are sufficiently reduced, the base plate is slightly tilted, thus contracting the area of the molten conductor at the high side. The metal at this point is therefore highly superheated with practically the normal power input; rotating the base plate changes the location of the superheated metal continuously, and the refining of the sulphur, manganese and carbon is thus effected. After tapping, the furnace may again be tilted to collect the molten conducting ring at the lower portions of the channels, when the entire furnace bottom may be inspected and repaired before proceeding with the next charge. (1,240,460; Sept. 18, 1917.)

**Alloy for Electric Resistance Elements.**—The ohmic effect of titanium in alloy compositions is the basis of a patent by WILBUR B. DRIVER of East Orange, N. J. Mr. Driver gives the following list of alloy compositions with the determination of the specific resistance for each:

| No.       | Percentage Composition |          |          |      |           | Specific Resistance |
|-----------|------------------------|----------|----------|------|-----------|---------------------|
|           | Nickel                 | Chromium | Titanium | Iron | Manganese |                     |
| No. 1...  | 75                     |          | 6        | 19   |           | 77                  |
| No. 2...  | 68                     | 15       | 4        | 11   | 2         | 117                 |
| No. 3...  | 65                     |          | 8        | 27   |           | 96                  |
| No. 4...  | 65                     |          | 6        | 19   | 10        | 106                 |
| No. 5...  | 60                     | 12       | 1        | 24   | 3         | 112                 |
| No. 6...  | 60                     | 12       | 6        | 19   | 3         | 125                 |
| No. 7...  | 40                     | 15       | 6        | 39   |           | 112                 |
| No. 8...  | 30                     | 10       | 6        | 54   |           | 117                 |
| No. 9...  | 30                     |          | 6        | 64   |           | 100                 |
| Copper    |                        |          |          |      |           |                     |
| No. 10... | 80                     | 10       | 3        |      |           | 48                  |
| No. 11... | 75                     |          | 8        |      | 17        | 57                  |
| No. 12... | 45                     | 45       | 3        |      | 7         | 77                  |
| No. 13... | 94                     |          | 5        | 1    |           | 32                  |

The advantages of these alloys are high melting points, durability and resistance to oxidation at high temperatures. The amount of titanium that can be used is limited only by the mechanical properties desired for drawing into wire and rolling into bars. Pure titanium is not a commercial product and even were it available, it would have too high a melting point for direct alloying purposes. Nickel-titanium and ferro-titanium are the present sources of supply. Owing to the relatively low specific gravity of titanium, it has a tendency to float, so that care should be exerted to entirely submerge it into the molten metals of the alloy. (July 30, 1918.)

**Ammonia Sulphate.**—A method of air oxidation of ammonia sulphite is patented by MESSRS HEINRICH DANNEEL and EMIL KUHN of Basel, Switzerland. The feature of their process is that calcium sulphite is formed according to the reaction:

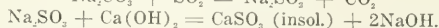
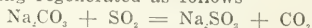


In this way the loss of ammonia is prevented as well as the formation of an acid free ammonia. (1,274,247; July 30, 1918.)

**Cleaning Metals.**—When silver, gold, etc., are placed in an electrolyte in contact with an electro-positive metal such as zinc, aluminium, etc., nascent hydrogen forms on the silver under enormous pressure and either pushes off all foreign matter or reduces it, so that a clean metallic surface is produced. Sodium bicarbonate was used first probably because some woman accidentally dropped a silver spoon into an aluminium dish contain-

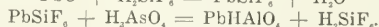
ing it, and discovered the "magic" way of cleaning silver. MESSRS. CHARLES B. MOREY and C. J. HUBER of Buffalo, N. Y., have found an improved electrolyte for this process in a slightly acidified solution of sodium chloride. Three per cent salt with one-tenth of one per cent hydrochloric acid is their preferred solution. The acid keeps the contact between the two metals clean besides furnishing more active ions. (1,274,186; July 30, 1918.)

**Calcium Sulphite.**—As an aid to the conservation of sulphur, MESSRS. HENRY HOWARD of Brookline and FRANK G. STANTIAL of Melrose, Mass., of the Merrimac Chemical Company, have developed a process for extracting sulphur dioxide from flue gases in the form of calcium sulphite, which can well be used as an intermediate for the manufacture of sulphite liquor for wood pulp manufacture. The flue gases are passed through sodium hydroxide solution, the  $SO_2$  reacting with the carbonate formed and the solution being regenerated as follows



Gas with as low a content of  $SO_2$  as 0.75 per cent has been successfully reduced to 0.10 per cent by this process. (1,271,899, July 9, 1918.)

**Lead Arsenate.**—The reaction between litharge and arsenic acid is greatly accelerated in the presence of hydrofluosilicic acid which dissolves the lead and thus furnishes an abundance of lead ions to react with the arsenate. The reactions are:



MR. I. P. LIHME of Lakewood, Ohio, in his patent specification, states that as small an amount as 1/200 equivalent of  $H_2SiF_6$  produces this reaction giving a soft, flaky, white precipitate that is admirably suited for insecticide spraying solutions. In the older methods of preparation, where arsenic acid acts directly on the solid litharge particles, the precipitate of lead arsenate forms a crust on the lead, which is a less efficient insecticide. (1,267,428; May 28.)

**Calcium Carbide.**—An improvement in the form of the carbon used in producing calcium carbide is patented by MR. ROBERT RUSSEL of Chicago, Ill., in which a 94 per cent fixed carbon hard pitch coke is thoroughly mixed with lime. Calcium carbide of ninety per cent purity is reported as obtained, which is a fraction better than the coal coke product. The acetylene gas obtained upon hydrolysis of this pitch carbide is free from many of the usual impurities, an important factor where this gas is to be used in the chemical synthesis of alcohol, acetic acid and acetone. (1,271,229, July 2, 1918.)

**Sodium Hydrosulphite.**—The reduction of sodium sulphite solution with hydrogen under high pressure as a substitute for zinc is patented by MR. A. K. GYUANDER of Westbrook, Maine. The reaction is simple:

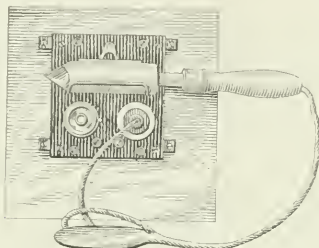


It is found that the velocity of the reduction varies with the pressure of the hydrogen, 100 lbs. per sq.in. pressure bringing about a 95 per cent conversion in 352 hours; 1456 lb., 24 hours, etc. (1,270,150, June 18, 1918.)



### Automatic Soldering Iron Rack

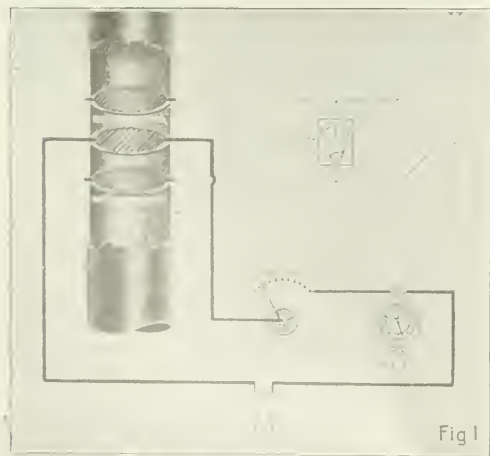
THE Cutler-Hammer Manufacturing Co. of Milwaukee have recently developed an automatic soldering iron rack and temperature control panel which decreases the amount of current taken by the iron while maintaining the working temperature. The rack consists of a small slate panel arranged for mounting and carrying a support for the soldering iron, which turns the elec-



tric current through a resistance circuit when weighted down. Taking the weight of the iron from the hook disconnects the resistance from the circuit and allows the full current to flow. A push button snap switch gives a convenient way of turning the current off and on without removing the soldering iron plug from the panel.

### The Thomas Gas Meter

IN THE present day of fuel conservation, bee-hive coke ovens are passing out and to a great extent coke gas is coming into use. In view of this, the Thomas meters manufactured by the Cutler Hammer Co. of Milwaukee, with a capacity of 500,000 cu. ft. per hour,



are an extremely interesting development. They embody the principle that, with a constant gas mixture, the specific heat is a function of its trade measurements. In the accompanying illustration Fig. 1 a sectional view of the gas main shows the arrangement of the electric resistance heating coil and the thermocouples. A differential of 2 deg. F. is maintained by means of the galvanometer control. The heat required to maintain

this temperature is measured by the current consumed through the watt meter, illustrated in Fig. 3, which, however, is graduated to 1000 cu. ft. of gas. A graph

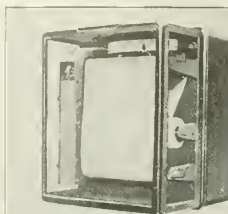


Fig 2



Fig 3

meter is also placed in the circuit, giving a time record of the rates of gas flow, Fig. 2. Daily gas analyses are made to check any variation in specific heat due to varying contents of hydrogen, methane, carbon monoxide, etc., and it is reported that no serious error arises from this source.

### Electrical Controlling Pyrometer

THE most precise electrical measurements are those made by a zero or balance method, such as the Wheatstone bridge and the potentiometer. In both no current flows through the galvanometer at the moment when the measurement is made and hence galvanometer errors are excluded. In the potentiometer, variations in the resistance of lead wires and of the source of electromotive force, such as a thermocouple, are also eliminated, the lead wires and thermocouple being in the same circuit with the galvanometer.

Zero methods, however, require external power for the balancing of the circuit. For single measurements this power is ordinarily supplied by the hand; a contact is moved along a slide wire or resistances are plugged in or out until the galvanometer comes to the zero position, when the quantity to be measured is at once known from the amount of resistance that has been used. The Leeds & Northrup Co., of Philadelphia has developed a line of power-driven recorders, however, in which the adjustments are made automatically, the galvanometer merely determining in which direction the adjustment is to be made.

Early attempts to use a galvanometer for this purpose were along the line of having the boom or pointer of the galvanometer close an electrical circuit. This, however, proved unsatisfactory, as with low voltages on the boom, contact would not be made through particles of dust, while with a higher voltage the boom would "freeze" or fuse to the contactor. In the Leeds & Northrup apparatus the boom serves merely as a mechanical trigger. A reciprocating part, kept in constant motion by a motor, is arranged not to strike the boom when the latter stands in the no-current position, but when the boom moves out of this position in either direction, the reciprocating part pushes it against another part which adjusts the bridge or potentiometer circuit, the amount of the adjustment being regulated according to the distance which the boom has swung, that is, to the unbalancing current through the galvanometer.

The power of the motor is sufficient, not only for making the adjustments, but also for the operation of the chart drum or roll. For this purpose, however, the motor must run at a constant speed, that is, sufficiently constant to give good time-keeping qualities, since the abscissae of the chart are laid off in hours and minutes. This has been found to necessitate the use of a special

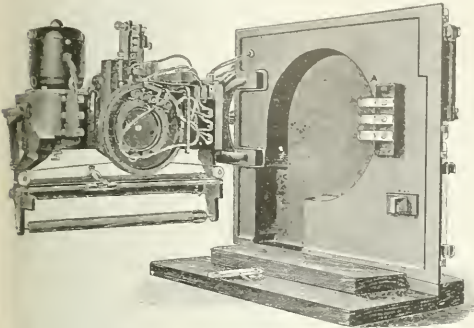


FIG. 1.—RECORDER OPEN FOR EXAMINATION

governor, and much time and research have been devoted to this problem. The governor finally adopted is of the centrifugal type and operates by opening and closing a shunt in the field circuit. When the motor is in operation this contact is continually on the make and break, as may be easily detected by listening to a telephone receiver connected in the circuit.

The motor not only adjusts the movable contact of the bridge or potentiometer, but also supplies power to move the recording pen. Multiple recording instruments which will record for a number of different thermocouples or resistance thermometers are also built. In these the motor operates the selector switch which connects the recorder to the different circuits and simultaneously turns a printing wheel which impresses upon the record sheet a dot to record the reading, and a number to identify the circuit which is being measured.

In the heat treatment of metals, it is becoming more and more the practice to bring the leads from thermocouples in different parts of the furnace and in different furnaces to a central control station. This is facilitated by the introduction of base metal thermocouples, which permits of the prolongation of the couple itself to the measuring instrument, where the effects of temperature upon the cold end of the couple are readily compensated for, and by the adoption of the potentiometer method of measurement, with which differences in resistance of lead wires become immaterial. An attendant at the control station uses an indicating instrument, which he connects successively to different thermocouples. Usually he is also provided with switches, by means of which he can light signal lamps for the guidance of the operators at the furnaces, usually a red light to indicate too high a temperature, a blue one to indicate too low a temperature and a white one to indicate the right temperature. A multiple-point recorder is generally installed to record the different temperatures automatically, one after the other. The Leeds & Northrup Multiple Recording Instruments, for example, are built for as many as 16 different circuits.

Where it is preferred to have the signaling at the furnace done automatically, a Leeds & Northrup "single-point" or curve-drawing recorder is provided with contacts on the moving element by means of which the signal lamps will be lit, accordingly as the temperatures in the furnace are too high, too low, or correct. An interesting extension of this plan is to use two thermocouples in different parts of the furnace and to provide the recorder with a commutator by means of which it reads first on one and then on the other. The chart produced is a single line running alternately back and forth between the two temperatures and indicating the temperature difference graphically. At the same time the commutator controls a fourth signal lamp at the furnace to show which thermocouple is being measured.

The double recorder is thus suitable for demonstrating uniformity of furnace temperatures, or the lack of it. It shows graphically the effects of empty furnace, full furnace, or part full furnace, and how distribution of heat is affected by rates of firing, location of load, door and other losses, cold hearth, etc. It is a convenient means for investigating furnaces and showing how errors may be overcome by moving burners, baffles, or arches, or changing the method of introducing heat, as by the use of side burners, underfiring, overfiring, number of burners, position of doors, etc. It also shows definitely the effects of location of thermocouples, how the readings vary according to their placing with respect to the work and the burners, also the number of couples to be used in a given furnace, etc.

The use of this double recorder has exploded the old "soaking heat" idea, since it demonstrates that it is practically impossible to bring many kinds of loads up uniformly to the desired temperature by holding the

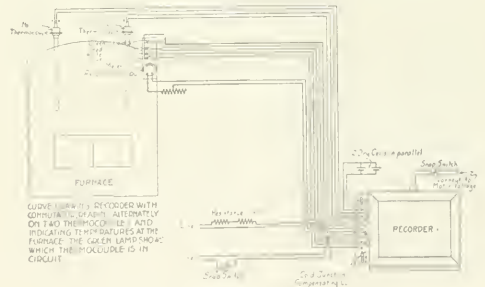


FIG. 2.—INSTALLATION WITH TWO THERMOCOUPLES

furnace at a "constant" temperature, without underheating some parts, and overheating others. This type of equipment has been found of especial value in studying the heating of different kinds and sizes of sections or numbers of pieces, different methods of loading, speed of loading and unloading, mechanical furnacing, the heat treatment of large single pieces, such as gun forgings, etc.

Atomizing Nozzle

IN THE mixing of corrosive chemicals, which must be brought together slowly because of their heat of reaction, etc., such as in nitrating, unsaturated coal-tar oils,

sulphur-chloriding oils for making rubber substitutes, etc., a recently developed stoneware nozzle placed on the market by the Monarch Manufacturing Works of 3129 Emery St., Philadelphia, Pa., will find a ready demand. As shown in the accompanying illustration, the upper part is a metal socket of lead or any desired metal or ma-

that provision be made to prevent the turning of the valve stem at the time of seating, a requirement provided for in this valve which insures a uniformly wearing plug and seat. The threads for operation are in a grease-packed casing in the handle. The valve can be packed under pressure, as a packing gland is adjusted

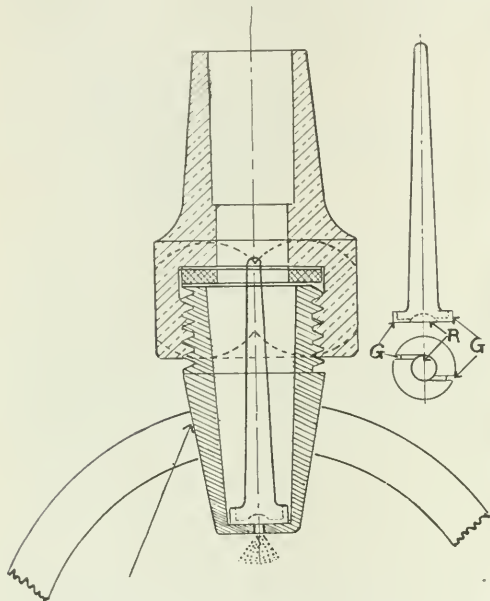


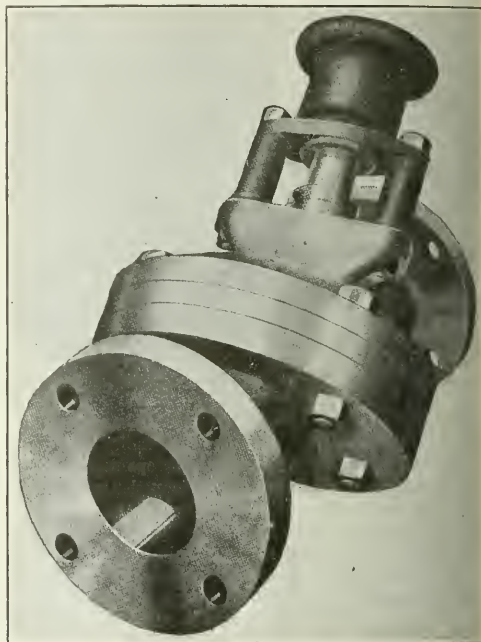
DIAGRAM OF ATOMIZING NOZZLE

terial for attaching the nozzle to the conductor of the liquid, into which the stoneware nozzle screws tightly against a gasket. The outside of the nozzle is conical, insuring a wedge fit in cases where it is desired to induct the spray through a terra cotta wall. The gyratory action, which produces the spray, is made by forcing the liquid through the two grooves *G*, which is then reflected radially by striking the walls of the eneral recess *R*, out through the nozzle opening. The rate of flow of the liquid will depend on its viscosity. For water, one gallon per hour for each 10 pounds per sq.in. of pressure may be figured, and for other liquids, the viscosity ratio can be applied for estimating purposes.

### Valves for Corrosive Liquors

THE weakest point in any valve, and especially in one for corrosive liquids, is the valve seat. The lead valves manufactured by the Chemical Equipment Company, Chicago Heights, Ill., have a double faced seat, which can be taken out, reversed or redressed without dismounting the valve body. The seat is provided with a straight cylindrical hole in the center and the tapered plug meets this in a single line contact. A feature of the line contact on a tapered plug is that, should there be a scale formation on the plug, the act of seating will crack off the scale and give a tight closure.

Lead being a comparatively soft metal, it is essential



VALVE FOR CORROSIVE LIQUORS

by means of a sleeve operating within the upper part of the yoke, the threads of which are grease packed.

#### GENERAL DATA ON LEAD VALVES

|                              |           |         |
|------------------------------|-----------|---------|
| Size .....                   | 1 1/2 in. | 2 in.   |
| Face to face of flanges..... | 8 1/2 "   | 10 "    |
| Diameter of flanges.....     | 4 1/2 "   | 5 1/2 " |
| Diameter of bolt circle..... | 3 3/4 "   | 4 1/2 " |
| Number of bolts.....         | 4         | 4       |
| Diameter of bolts.....       | 3/8 "     | 1/2 "   |
| Approximate weight.....      | 58 lbs.   | 62 lbs. |

### Gas Rivet Heaters

Gas is to be used exclusively for rivet heating, plate bending and general fabricating heating purposes hereafter at the Bethlehem Shipbuilding Corporation's Alameda plant. This is a radical departure from the ship-building methods that have been in use for years, whereby it was thought that only coke could be used—even oil was considered an innovation. Good work by a riveting crew depends to a great extent on properly heated rivets. With a continuous and uniform gas forge, the heater man can give his undivided attention to regulating the forge so that there will be no burned nor underheated rivets, irrespective of the speed at which the crew works. This tends toward regularity, with properly upset and tight, full-headed rivets as a result. The cooling contraction is likewise more uniform and caulking is reduced to a minimum.



## Synopsis of Recent Chemical and Metallurgical Literature

**Combustion of Producer Gas.**—V. HASSREDTER, in *Metall. und Erz.* Vol. XV, page 139, gives calculation formulae for the excess of air used in combustion of producer gas. When a volume,  $G$  of producer gas is burned, the volume of air,  $L$ , required is not  $R - G$  as commonly stated, but  $R - G + c - d$ , where  $R$  is the volume of products of combustion,  $c$  the contraction and  $d$  the contraction due to combustion. For each volume of each of the following gases, when dry, the respective values of  $c$  are:  $C_2H_4$  or  $C_2H_2$ , 2.5;  $CH_4$  or  $C_2H_6$ , 2.0;  $H_2$  or  $C_2H_4$ , 1.5;  $CO$ , 0.5. When the volume of the moist products of combustion is taken, neither expansion nor contraction occurs in the combustion of methane and ethylene; hydrogen and acetylene contract 0.5 vol.; but with ethane and benzene, expansion ( $d = .5$ ) occurs. If  $L_0$  = the volume of air theoretically necessary, and  $L$  = the excess of air admitted,  $L_0 = R - L - G + c - d$ . This equation is applicable to moist flue gases if the volume of the water-vapor in them is taken into consideration. On the customary assumption that  $L = R - G$ , the ratio  $\frac{L}{L_0}$  may have only half its proper value.

If  $E$  = the percentage of air in excess of that theoretically of combustion,  $X$  = volume of oxygen theoretically necessary,  $x$  = the excess of oxygen in the product required for the combustion, and  $R$  = the volume of products of combustion,  $E = \frac{100 Rx}{X}$ . Fischer's ratio,

$\frac{21}{21 - 79 \frac{o}{n}}$  : 1 (where  $o$  = per cent of oxygen and  $n$  =

per cent of nitrogen in the products of combustion), is applicable to coal, coke and illuminating gas, but not to producer gas and other fuels containing a considerable percentage of nitrogen. Furthermore, use of the percentage of nitrogen in the products of combustion as a basis for calculating the excess of air present is unsatisfactory, since a variation of 10 per cent in the latter causes a variation of only 0.1 per cent in the nitrogen, but a variation of 8 per cent in the free oxygen.

"The Estimation of Tin in High-Grade Wolframite and the Use of Lead as a Reducing Agent in Pearce's Assay" was the subject of a paper read by A. R. POWELL at the June meeting of the London section of The Society of Chemical Industry.<sup>1</sup> Four methods were discussed for the quantitative separation of small quantities of tin from rich tungsten ores, two of which were devised by the author. In the older methods the ore was boiled with aqua regia, the insoluble stannic and tungstic oxides filtered and extracted with ammonia, the residual stannic oxide being fused with sodium peroxide and the assay continued in the usual way; or the ore may be fused with cyanide and the ferro-stannic residue dissolved in hydrochloric acid and the solution reduced and titrated.

The author's first method consists of fusing the ore with sodium peroxide and making the melt up to a

known volume with water. An aliquot portion is filtered off and the tin separated either by boiling the solution with ammonium nitrate, or the alkaline solution is acidified with tartaric acid together with a slight amount of hydrochloric acid, then the tin is precipitated with hydrogen sulphide.

In the second method, the ore is fused in sodium acid sulphate and the melt boiled with tartaric acid, which dissolves everything except tin oxide and gangue; then the insoluble residue is filtered and fused in sodium peroxide. Copper, bismuth and molybdenum are removed by extracting the ore with nitric acid.

The author has found that stannic chloride solutions can be reduced satisfactorily by lead or zinc-lead instead of iron, it being unnecessary to remove the lead in order to titrate; moreover, the solution is colorless. This method is a rapid one, since sixteen to twenty assays can be made by it per hour.

**Lignin from Sulphite Waste Liquors.**—An article in *Svensk Pappers-Tidning* by MR. R. W. STREHLENER gives an account of a process for the precipitation of the dissolved colloidal lignin. As there is practically a ton of organic matter carried away in the waste liquor to every ton of dry pulp made, five-eighths of which are lignin, one-fourth other carbohydrates, and the remainder resins and organic acids, the importance of recovering and utilization of this material is obvious. Klason has determined the molecular weight for lignin to be about 6000, which would indicate an approximate formula of  $(C_6H_7O_2)_n$ . The lignin is in solution in the waste liquor as a calcium ligno-sulphonite salt. Strehlener finds that at the critical temperature, at which  $SO_2$  is given off by decomposition, oxygen rapidly acts on the sulphite ions giving sulphate ions, which form lime salts insoluble in the presence of excess  $SO_2$  and thus break up the complex ligno-compounds. As the reaction,  $3SO_2 \rightarrow 2SO_3 + S$ , takes place under the conditions of temperature and pressure used, air is not essential for the decomposition (phenomenon called "black cook in papermaking") but a coarser precipitate is obtained with air oxidation, which is more easily filtered and dried. Strehlener is using the dried filter cake for fuel at Gota, Norway. As coal is cheaper in America and labor more expensive than in Norway, it is doubtful whether lignin would be an economical fuel.

**Discoloration of White Paint.**—At a recent meeting of the Society of Chemical Industry at Birmingham, Eng.,<sup>1</sup> Dr. D. F. Twiss discussed the yellowing of white paints. Lead, zinc and barium pigments were found to be equally susceptible and the evidence indicated that the source of discoloration was not in the pigment but in the oil. When a little of the oil was separated from the paint and absorbed into paper free from mineral impurities, the dried film, on being kept in a warm place, was found to develop gradually a marked yellowish brown color. Bleached films were immediately disclosed by keeping in a warm place unexposed to actinic action and the discoloration and bleaching processes were repeated many times in succession, the tendency to discolor undergoing but slight diminution. Artists have found that walnut and poppy seed oils have less tendency to turn yellow, but for commercial work, linseed is the oil par excellence.

## Book Reviews

**EDIBLE FATS AND OILS.** By C. Ainsworth Mitchell, B. A., F. I. C. Pages, 159. Price, \$2.00. New York and London: Longman, Green & Co.

This little volume is one of the Monographs on Industrial Chemistry, edited by Sir Edward Thorpe, C.B., LL.D., F. R. S.

As stated in the preface, it gives a "concise outline of the chemical composition and properties of the more important oils and fats, together with a description of the methods of extracting them from the crude material and of purifying them for food purposes."

Although the author has worked with the end in view of giving principles rather than working details of the various analytical processes mentioned, he has succeeded in a wonderfully small space in giving very full information regarding modern methods of oil and fat investigation, while the tables of constants and thirty-three pages of bibliography make it a valuable work of reference to the specialists.

The portion of the work dealing with manufacturing processes is little more than a sketch and is in no way to be considered as a guide to their application, but rather a source of general information.

The chapters on hydrogenation and margarine manufacture considered as short general outlines are particularly good, while a very complete index adds greatly to the value of the volume as a concise book of reference.

**PETROLEUM, ASPHALT AND NATURAL GAS.** By Roy Cross. Pages (5 x 7½), 212. Price \$2.00. Kansas City, Missouri: Kansas City Testing Laboratory.

This little leather-bound volume is Bulletin No. 14 of the Kansas Testing Laboratory. It is very practical and well-nigh indispensable to petroleum and gas chemists, having statistics, physical, chemical and pneumatic tables and many illuminating features. The table on page 62-63 on "Horizontal Cylindrical Tank" segments should have had some explanatory remarks—and should have included spherical lumps and steam coil segments, besides referring to the published actual calibrations of tank cars by name and number. Twenty blank pages are reserved for notes facilitating additions to the volume.

**THE ALKALI INDUSTRY.** By J. R. Partington. Pages (demy octavo) 304. Price, \$1.80. London: Baillière, Tindall & Cox.

The title of this book is not sufficiently inclusive since the author devotes over 60 per cent of its space to sulphuric and nitric acids, chlorine and iodine. The treatment of the salt industry, soda processes, electrolytic processes, ammonia, potash and magnesia is less elaborate than desirable, being too extensive for the general reader and of little practical value in training an alkali chemist. The many modern electrolytic cells are not even mentioned in the eight-page chapter on "Electrolytic Processes." In the contact process for the manufacture of sulphuric acid and the oxidation of ammonia to nitric acid, the reader will find an introduction to the great recent developments in this branch, but of course no complete accounts will be available under present international conditions.

MR. JOHN C. MERRILL is the successor to the firm of Sulliger and Merrill, located at 1400 Hibernian Building, Los Angeles, California.

PROFESSOR JULIUS STIEGLITZ, chairman of the department of chemistry at the University of Chicago, has been appointed special expert in the United States Public Health Service of the Treasury Department. This will not involve his work at the university. The government assigns him two assistants, who will be in the employ of the Public Health Service and will carry out their work in Kent Chemical Laboratory under Professor Stieglitz's direction.

MR. SAMUEL WIERMAN has resigned his position as chief chemist at the Citrus By-Products Company, Corona, California, to accept the position of chemist-in-charge of the Chemical and Agricultural Department of the Société Financière des Caoutchoucs of Antwerp, Belgium, and London, England. The scientific departments of the Société are located in the Federated Malay States, convenient to their rubber plantations in the Malay States, Sumatra and Java.

## Current Market Reports

### Non-Ferrous Metal Market

**Wednesday, August 7.**—Prices have remained stationary during the past two weeks. Government price-fixing seems to have served as an antidote for speculating.

**Aluminum.**—The government prices on ingots are 33c. a pound f.o.b. plant in 50-ton lots, 33.1c. down to 15-ton lots and 33.2c. in lots down to 1 ton, which prices will be effective until September 1. Prices for small lots vary from 40c. to 45c.; sheet aluminum, 18 ga., and heavier, 42c.; powdered aluminum, \$0.65 to \$3.00 per pound, according to mesh.

**Antimony.**—The demand is very weak and spot duty paid has fallen in price, 13c. to 13½c.

**Chrome.**—Large quantities of high-grade material have been sold at a premium, 50 per cent ore bringing \$1.70 per unit.

**Copper.**—Government price fixed at 26c. for carload lots and 27.3c. for smaller quantities is expected to be changed on August 15. A conference is being held between the producers and the War Industries Board, and it is probable that no official increase in price will be allowed without considerable delay and presidential sanction.

|                              |     |        |          |
|------------------------------|-----|--------|----------|
| Copper sheets, hot rolled... | lb. | \$0.36 | — \$0.37 |
| Copper sheets, cold rolled   | lb. | .37    | .38      |
| Copper bottoms.....          | lb. | .44    | .43      |
| Copper rods.....             | lb. | .36    | .37      |
| Copper wire.....             | lb. | .29    | .29      |
| High brass wire.....         | lb. | .28    | .29      |
| High brass sheets.....       | lb. | .26    | .28      |
| Low brass wire.....          | lb. | .32    | .34      |
| Low brass sheets.....        | lb. | .32    | .34      |
| Low brass rods.....          | lb. | .33    | .35      |
| Brazed brass tubing.....     | lb. | .37    | .39      |
| Brazed bronze tubing.....    | lb. | .42    | .44      |
| Seamless copper tubing.....  | lb. | .41    | .43      |
| Seamless bronze tubing.....  | lb. | .45    | .46      |
| Seamless brass tubing.....   | lb. | .37    | .39      |
| Bronze (gold) powder.....    | lb. | 1.00   | 1.75     |

**Lead.**—Demand strong with supplies scarce. War consumption has been exceptionally heavy. A limited quantity of prompt lead is quoted at 8½c. to 8¾c. September and October deliveries prices in New York, 8.05c. per lb.; East St. Louis, 7.75c. in 60,000-lb. lots; full sheet lead, 10c.; cut sheets, 10½c.

**Manganese.**—Prices remain at \$1.35 per unit basis.

**Molybdenum.**—Domestic demand still lacking. The price is nominally \$1.00 per unit of 90 per cent MoS<sub>2</sub>.

**Spelter.**—Spot delivery in New York is quoted at 8.5c. to 8.6c. for prime Western. East St. Louis, all positions to the end of the year range between 8.1c. and 8.2c. Sheet zinc is 15c. and zinc dust, 16c. to 20c. per pound in 1600-lb. barrels.

**Tin.**—Owing to river floods in China, transportation of tin there has been interrupted, with consequent advance in Singapore prices to 98½c. f.o.b. London. Open market in New York dull with prices varying between 92c. and \$1.00. Babbitt metal varies between \$1.10 and 70c. per pound. Solder 50-50, 73c.

## Personal

MR. STUART B. MARSHALL, formerly manager of the American Manganese Manufacturing Co., Dunbar, Pa., and until recently general superintendent of the Aluminum Company of America's properties and business in North Carolina, at Badin, is now located at Roanoke, Va., as consulting engineering chemist and metallurgist for coal and ore lands, blast furnaces, manganese pyrites, antimony, lead and zinc deposits, ferromanganese and spiegel operations, minerals, etc.

**Tungsten:**—The British government has attempted to steady the tungsten industry by guaranteeing a price of 60 shillings a unit for the duration of the war and six months thereafter. The highest grade material, containing no tin, no copper and low manganese and over 70 per cent Wo., is selling at \$25.50 per unit. Lower grades vary between \$20.00 and \$24.00.

#### OTHER METALS

|              |        |        |         |
|--------------|--------|--------|---------|
| Bismuth ..   | lb.    | \$3.50 | —\$3.65 |
| Cadmium ..   | lb.    | 1 50   | —       |
| Cobalt ..    | lb.    | 2 50   | — 3 50  |
| Magnesium .. | lb.    | 1 75   | — 2 00  |
| Mercury      | 75 lb. | 125 00 | —       |
| Mercury      | lb.    | 1 95   | —       |
| Nickel ..    | lb.    | 40     | — 43    |
| Iridium ..   | oz.    | 175 00 | —       |
| Palladium .. | oz.    | 135 00 | —       |
| Platinum ..  | oz.    | 105 00 | —       |
| Silver ..    | oz.    | 99     | —       |

### The Iron and Steel Market

Further regulations have been made by the War Industries Board for the distribution of steel, in addition to those summarized in last report. Jobbers, who were accorded a B-4 preference for the replacement of material, month by month, that had been shipped the previous month on priorities and preferences, are given special treatment as to mill shipments to them for August, this taking the place of the regular procedure, which becomes effective for September. For August the mills are permitted to ship jobbers an amount of material equal to the monthly average shipped during the first half of the year. In some finished steel branches, like wire products and pipe, the mills can do fairly well under these regulations, but in sheets, merchant bars and some other products it is represented that by the time higher preferences are provided for there will be little if any material left to take a Class B-4 rating.

What is called "automatic priority" is provided for many descriptions of steel, each use prescribed being given its particular priority, as AA-2, A-3, B-6, etc. The buyer, when placing his order, makes a formal endorsement on it, certifying the use to which the material is to be put and naming the degree of priority that is accorded by the regulations. Commercial buyers must make affidavit; representatives of the Government need not. While this arrangement as to "automatic priority" seems like a radical step, in essence it is but a natural development, in that the Priorities Division as it gained experience had developed certain rules for its guidance in determining the degree of priority, if any, and when the rules became sufficiently stabilized procedure under them was simply handed over to the buyers.

These priorities, in the present complicated form, must be regarded purely as expedient to meet an undesirable condition, it is hoped, a temporary situation. After the priorities come the preferences, and then Class D material, for purposes that are given no recognition. Obviously there is no occasion for a priority order for a given description of material if there is a supply of it left for the preference list, and obviously it is highly undesirable that there should be none of such material for the preference list, not to mention Class D consumers. The priority order does not alter the conduct of a mill if it can make the desired delivery without. It is only when the delivery desired by the buyer cannot be made otherwise that the priority order operates. Hence if there is enough steel for all the priorities they disappear as a governing factor. Eventually, it is hoped, priorities will become purely a matter of form and the desired deliveries will be made without their influence being exerted. The War Industries Board reserves the right to modify the priorities produced by the automatic system, in any particular case, and of course many uses are not covered by the list and the steel for such uses will still be given individual priority orders by the board.

#### STEEL REQUIREMENTS

While in July the War Industries Board made the statement that the finished steel requirements for the second

half of the year amounted to between 20,000,000 and 21,000,000 net tons, while output had never exceeded 16,500,000 net tons, in conferring subsequently with the Fuel Administration, as to supplies of bituminous coal for the steel industry, it stated that the requirements were 22,000,000 tons, so that it evidently had not given up hope of the industry being able to produce more than 16,500,000 tons. This hope is well founded. The rate of production in May and June was nearly if not quite 3,000,000 tons, while July has done almost as well, despite the season of the year, and gains on 3,000,000 tons a month are therefore to be expected for the fall months, with possibilities therefore of 18,000,000 to 19,000,000 tons for the half year.

Some details have been furnished the steel makers as to how the total for the half year is made up, and the statement has also been made that the requirements for the first half of 1919 promise to run 20,000,000 tons or more. The steel industry is disposed to take the schedule as correct, although there remains some doubt whether the various activities will really be able to operate at expected rates and use the steel within the periods prescribed.

All estimates are necessarily rough as in all activities the greatest pressure is being applied, and this pressure will naturally be more successful in producing results at some points than at others. No activity is being curbed to suit the pace of another activity. In shipbuilding there is the shipment of the steel, the fabricating at detached plants, the work on the shipways and the work in the fitting out basins, with a thousand things to be supplied the ship before it is completed. Theoretically, the Director of Shipbuilding would apply pressure where most needed but his conduct to date has been that of applying pressure everywhere, showing no favoritism. Boilers are the crying need when he talks to boiler makers, the driving of rivets when he talks to the shipyard workers, and so all along the line.

#### WAR ACTIVITIES

There have been heavy lettings of shell contracts, involving a material increase in the rate of shell steel consumption. If the production of shell steel has not already exceeded a rate of 500,000 net tons a month it probably will do so in the near future. Since the first of the year there has been a large increase in the forging capacity for large shells, particularly 6-inch and larger, in which there was formerly a marked deficiency. With the demand running more largely to steel for large shells the burden upon the steel industry in the matter of rolling the steel is decreased, while the amount of steel subtracted from the supply to finishing departments in general is increased.

The plate allotment for shipbuilding in the United States is 50,000 net tons a week, or about 2,600,000 tons a year. Estimated production, including universal mill plates, is about 6,000,000 tons a year, nearly double the actual output of 1916, which represented approximately the existing capacity at the time. Further increases in plate production are in sight, through new construction, and by the end of the year there may be an increase of as much as 50,000 or 75,000 tons a month over the present rate. This heavy production of plates operates as does the heavy production of shell steel, to take raw steel out of the general situation and force finishing departments making less essential products, or products that are called for by war activities in smaller proportions, to operate at far below their capacity. Taking the rod mills, pipe mills, sheet mills and merchant bar mills as a whole, their operation is not over about 65 per cent of capacity.

#### NEW CONSTRUCTION CONSIDERED

This situation, coupled with the fact that the byproduct coking capacity has been increasing steadily and is marked for indefinite increase in future, as even in the past three months new plants have been projected, some with financial assistance by the Government, has led to an investigation of new construction as a means of providing more steel. It is readily seen that a fully integrated operation need not be constructed. There would probably be enough coke making capacity, if supplied with coal, also enough iron ore, at least for a time, and there would be enough finishing capacity,



if the present output of the finishing departments that are being operated at less than capacity is not sufficient for the war requirements, direct and indirect. Indications pointed strongly to the fact that additional blast furnaces and open-hearth furnaces, with perhaps an occasional blooming mill and slabbing mill, would increase the steel industry's capacity effective for war work. At the same time, viewed from the standpoint of the normal requirements of peace times, there would be left an excess of pig iron and steel making capacity. Accordingly the matter has been canvassed of the Government extending financial assistance in connection with the new construction, against which heavy amortization charges would have to be laid in view of the conditions. At the same time the influence of the War Industries Board would have to be invoked to provide the necessary man power and materials. To an extent yet to be determined, so far as is now known, this would be to the detriment of other war activities. Formal announcement of a decision on this matter may or may not be made in the near future.

#### STEEL PRICES

The very large profits and earnings being reported by steel companies indicate very clearly that there is no prospect of the War Industries Board advancing prices at any time. There may be some rearrangements of schedules, but no general advance is in prospect, and there may easily be horizontal reductions. The argument that some producers make much smaller profits than large producers has not been supported by citation of an adequate number of cases. The arguments are usually confined to generalities. Nor does the argument that wage advances increase cost of production and increased cost of production should be followed by advanced prices follow a logical sequence. The wage advances have as a rule been based upon the large earnings the employers were already enjoying.

#### Chemical Market

**HEAVY CHEMICALS:**—The market in general has not shown very great activity. Saccharine, both grades, has been on strong call with consequent appreciation in prices, but with regard to caustic there has been some uncertainty of just what might occur in view of the new Government regulations. Some discussion was raised also as to what might constitute a reasonable profit to dealers in sulphuric acid, but this has been dropped and business is continuing to be done at whatever the buyer is willing to pay.

**Glycerine:**—No definite confirmation has been received locally of the press dispatches from Washington concerning the so-called fixing of glycerine prices. Nevertheless, the trade is of the opinion that the matter has been definitely decided and that only an official announcement remains to be made. The prices are stated to be 60c., August-September; 58c. for October-November and 56c. for December. This of course is for dynamite glycerine. As we have before mentioned, the matter of a fixed price for dynamite glycerine was only a matter of time, although the War Industries Board has stated that they did not see the necessity of such a fixed price at the moment. However, the Food Administration thought otherwise and as it is known that the allied governments are about to purchase large quantities on this market the price fixing arrangement has at last materialized. There is practically no spot market at the present, although refiners express a willingness to sell at 60c. C.P. holds at 62c. The crude situation is much weaker and refiners claim purchases at 40c. loose for soap lye and 44c. for saponification.

**Metabisulphite of Potash:**—Prices asked for this material show a slightly advanced level due to the government taking the majority of the supplies available and very little being offered on the open market. Some lots are to be had but they are said to be small. Crystal material is held at from 1.20 to 1.40 with the powdered at from 1.10 to 1.20.

**Metabisulphite of Soda:**—This item has not been very active and prices quoted continue at about 30c. Large quantities, however, could be purchased at a lower figure, possibly 25c. in ton lots.

**Sodium Sulphide:**—Actual holders of spot lots of material are very hard to locate with the exception of one lot for immediate delivery at 8c. Prices are being quoted f.o.b. factory at 6.50, although a single sale was lately reported of material for September shipment at 2.00 advance over this figure.

**Carbon Tetrachloride:**—For a long time the Government requirements have been more than they were receiving, but leaving then but a small amount for the open market. It is understood that now not a pound can be distributed to consumers without first submitting questionnaire to Washington. Only one or two drums are still in second hands, but these cannot be bought for less than 28c. at the least.

**Caustic Soda:**—In some directions sellers are asking 4.25 but demand is very quiet and in some instances sales have resulted at below the market, in one particular a carload at 3.90 ex store for standard material.

**Bichromate of Soda:**—A rather unusual lull prevails in the situation, and nominally the market remains at 26c. Some interests are of the opinion that something is going to happen. Tanneries would no doubt welcome a fixed price such as the Government has established on hides but a fixed price on the chemical would necessarily mean a fixed price on chrome ore and a regulated source of supply of this raw material. Developments may be expected in other directions it is reported as an official of the Government is known to have been gathering data relative to numbers of producers, quantities produced and so forth, but nothing has yet been heard from Washington definitely.

**COAL TAR PRODUCTS:**—Not very great activity has been evident and all the coal tar items have held rather steady with regard to price excepting particularly saccharine, which continues to make firm progress, with a tendency toward a resuming of the former relations between the two grades.

**Phthalic Anhydride:**—Inquiries have been rather strong for this material and the supplies which have been fast lowering are said to be about exhausted. It is now practically impossible to place an order for prompt shipment and the best that can be done is October. Prices, therefore, are showing a firmness with quotations from 4.75 to 5.00 f.o.b. works.

**Saccharine:**—The general askings where there are actual holdings of material are at 36.00 for the soluble, to which level the askings for insoluble also advanced with a tendency to again assume a precedence, as at this writing it is understood that this latter grade is being quoted in several directions at 37.00 and 38.00. Some of the holders of soluble have been holding back their stocks for better prices; but undoubtedly now, with the preference being shown for insoluble, they will let material out. Certain holdings available for export, having affidavit attached, are at 45.00.

**Coumarin:**—Manufacturers are behind in their shipments and dealers having contracts are therefore unable yet to accept orders for immediate delivery. It is understood that manufacturers are not able even to state when they will be in a position to supply. Inquiry is strong and there are buyers willing to pay 32.50. Large inquiries for export material are also extant.

**Paranitrophenol:**—Supplies are said to be not very large and prices are firm at from 1.65 to 1.75 with good inquiry. From some directions quotations are made at from 1.60 to 1.70 for the needle crystals, depending upon quality and quantity.

**Orthonitrophenol:**—In general stocks are rather short although certain directions are understood to be preparing to take care of large orders. Very little spot material is available and most directions are quoting for future deliveries; that is, September first and after. Prices continue firm at from 1.50 to 1.60 f.o.b. works.

**Guaiacol Liquid:**—The price of 15.00 per pound holds firm as asked by some of the largest factors in its production. Although it is said that present supplies are about sufficient to take care of the present demand, this latter is

growing and preparations for meeting it by enlarged manufacturing facilities and shipments on the new scale are expected to be made shortly.

**Para-amidophenol.**—Prices quoted on this item continue firm at from 4.00 to 4.50 for the base and from 4.25 to 5.00 for the H.C.L., depending upon quantity.

**Orthoamidophenol.**—Prices remain unchanged as the general askings by the few holders are at 6.50 on orders for reasonable amounts, although on attractive business this would undoubtedly be shaded.

## General Chemicals

WHOLESALE PRICES IN NEW YORK MARKET, AUG. 9, 1918

|                                                |         |               |        |
|------------------------------------------------|---------|---------------|--------|
| Acetic anhydride                               | lb.     | 1.60          | 1.85   |
| Acetone, drums                                 | lb.     | .35           | .40    |
| Acid, acetic, 28 per cent                      | lb.     | .065          | .067   |
| Acetic, 50 per cent                            | lb.     | .13           | .14    |
| Acetic, glacial, 99½ per cent, carboys         | lb.     | .36           | .40    |
| Boric, crystals                                | lb.     | .134          | .15    |
| Boric, crystals                                | lb.     | .62           | .88    |
| Hydrochloric, C. P.                            | lb.     | .08           | .08    |
| Hydrochloric, 20 deg.                          | lb.     | .02           | .02½   |
| Hydrochloric, conc., 22 deg.                   | lb.     | .021          | .03    |
| Hydrobromic, 30 per cent in barrels            | lb.     | .15           | .16    |
| Lactic, 44 per cent                            | lb.     | .13           | .14    |
| Lactic, 22 per cent                            | lb.     | .06           | .07    |
| Molybdenic, C. P.                              | lb.     | 6.90          | 7.40   |
| Nitric, 36 deg.                                | lb.     | .08           | .10    |
| Nitric, 42 deg.                                | lb.     | .08½          | .10    |
| Oxalic, crystals                               | lb.     | .42           | .44    |
| Phosphoric, 47-50 per cent paste               | lb.     | .08           | .10    |
| Phosphoric, ref., 50 per cent                  | lb.     | .35           | .40    |
| Picric                                         | lb.     | .75           | .85    |
| Pyrogallol, resublimed                         | lb.     | 3.25          | 3.50   |
| Sulphuric, 60 deg.                             | ton     | 18.00         |        |
| Sulphuric, 66 deg.                             | ton     | 28.00         |        |
| Sulphuric, oleum (Fuming), tank cars           | ton     | 60.00         | 65.00  |
| Tannic, U. S. P., bulk                         | lb.     | 1.48          | 1.53   |
| Tartaric, crystals                             | lb.     | .86           | .95    |
| Tungstic, per lb. of W                         | lb.     | 1.70          | 1.75   |
| Alcohol, sugar cane, 188 proof                 | gal.    | 4.91          |        |
| Alcohol, wood, 95 per cent                     | gal.    | .91           | .92    |
| Alcohol, denatured, 180 proof                  | gal.    | .61           | .62    |
| Alum., ammonia lump                            | lb.     | .05½          | .05    |
| Alum., chrome ammonium                         | lb.     | .18           | .19    |
| Alum., chrome potassium                        | lb.     | .20           | .21    |
| Alum., chrome sodium                           | lb.     | .08           | .09    |
| Alum., potash lump                             | lb.     | .09½          | .10    |
| Aluminium sulphate, technical                  | lb.     | .02           | .02½   |
| Aluminium sulphate, iron free                  | lb.     | .03½          | .04    |
| Ammonia, aq., 26 deg., carboys                 | lb.     | .12           | .16    |
| Ammonia, anhydrous                             | lb.     | Nominal       |        |
| Ammonium carbonate                             | lb.     | .13           | .13½   |
| Ammonium nitrate                               | lb.     | (Fixed Price) | .15    |
| Ammonium, sulphate domestic                    | lb.     | .07½          | .08    |
| Amyl acetate                                   | gal.    | 5.30          | 5.35   |
| Arsenic, white                                 | lb.     | .09½          | .10    |
| Arsenic, red                                   | lb.     | .07           | .07    |
| Barium carbonate, 99 per cent                  | ton     | 80.00         | 90.00  |
| Barium carbonate, 97-98 per cent               | ton     | 65.00         | 67.00  |
| Barium chloride                                | ton     | 65.00         | 70.00  |
| Barium sulphate (Blanc Fixe, Dry)              | ton     | .04           | .05    |
| Barium nitrate                                 | lb.     | .12           | .14    |
| Barium peroxide, basis 70 per cent             | lb.     | .30           | .32    |
| Bleaching powder, 35 per cent chlorine         | lb.     | .02           | .03½   |
| Borax, crystal blocks                          | ton     | .07½          | .10½   |
| Bromine, crude                                 | ton     | 65            | 70.00  |
| Bromine, technical                             | lb.     | .75           |        |
| Calcium, acetate, crude                        | lb.     | .14           | .16    |
| Calcium, carbide                               | lb.     | .08           | .05    |
| Calcium chloride, 70-75 per cent, fused, lump  | ton     | 22.00         | 24.00  |
| Calcium peroxide                               | lb.     | 1.50          | 1.70   |
| Calcium phosphate                              | lb.     | .22           | .23    |
| Calcium sulphate, 88-99 per cent               | lb.     | .09           | .09½   |
| Carbon bisulphide                              | lb.     | .08½          | .09    |
| Carbon tetrachloride, drums                    | lb.     | .15           | .28    |
| Calcium chloride (phosphate)                   | lb.     | 1.10          | 1.50   |
| Caustic potash, 85-92 per cent                 | lb.     | .75           | .77½   |
| Caustic soda, 76 per cent                      | 100 lb. | 4.00          | 4.25   |
| Chlorine, liquid (Government Purchase)         | lb.     | (Fixed Price) | .07½   |
| Chalk, oxide                                   | lb.     | 1.60          |        |
| Copperas                                       | lb.     | .02           | .02½   |
| Copper carbonate                               | lb.     | .29           | .32    |
| Copper cyanide                                 | lb.     | .75           | .78    |
| Copper sulphate, 99 per cent, large crystals   | lb.     | .09½          | .09½   |
| Cream of tartar, crystals                      | lb.     | .68           | .82    |
| Epsom salt, bags, U.S.P.                       | lb.     | 3.62½         | 3.90   |
| Formaldehyde, 40 per cent                      | lb.     | .16½          | .17½   |
| Glauber's salt                                 | lb.     | .02           | .03    |
| Glycerine, bulk, C. P.                         | lb.     | .62           | .65    |
| Iodine, resublimed                             | lb.     | 4.25          | 4.30   |
| Iron oxide                                     | lb.     | .13           | .15    |
| Lead acetate, white crystals                   | lb.     | .17           | .17½   |
| Lead arsenate (Paste)                          | lb.     | .15           | .18    |
| Lead nitrate                                   | lb.     | Nominal       |        |
| Litharge, American                             | lb.     | .14           | .14    |
| Lithium carbonate                              | lb.     | 1.50          | 2.05   |
| Magnesium carbonate, technical                 | lb.     | .14           | .13    |
| Nickel salt, single                            | lb.     | .14           | .14    |
| Nickel salt, double                            | lb.     | .12           | .13    |
| Phosgene, (see Carbonyl chloride)              | lb.     | 1.10          | 1.50   |
| Phosphorus, red                                | lb.     | 1.15          | 1.20   |
| Phosphorus, yellow                             | lb.     | 1.35          | 1.40   |
| Potassium bichromate                           | lb.     | 4.45          | 4.60   |
| Potassium bromide granular                     | lb.     | 1.35          | 1.36   |
| Potassium carbonate calcined, 85-90 per cent   | lb.     | .38           | .40    |
| Potassium chlorate, crystals                   | lb.     | .41           | .41    |
| Potassium cyanide, 98-99 per cent              | lb.     | 3.75          | 3.80   |
| Potassium iodide                               | lb.     | 300.00        | 350.00 |
| Potassium murate 80-85 p. c. basis of 80 p. c. | ton     |               |        |
| Potassium nitrate                              | lb.     | .27           | .31    |

|                                                 |         |         |       |
|-------------------------------------------------|---------|---------|-------|
| Potassium permanganate U. S. P.                 | lb.     | 1.50    | 2.00  |
| Potassium prussiate, red                        | lb.     | 2.60    | 3.50  |
| Potassium prussiate, yellow                     | lb.     | 1.05    | 1.15  |
| Potassium sulphate, 90-95 p. c. basis 90 p. c.  | ton     | Nominal |       |
| Rochelle salts                                  | lb.     | .44½    | .46   |
| Salammoniac, gray gran                          | lb.     | .22     | .23   |
| Salammoniac, white gran                         | lb.     | .17½    | .21   |
| Salt soda                                       | 100 lb. | 1.75    | 1.80  |
| Salt cake                                       | ton     | 35.00   | 40.00 |
| Silver cyanide, based on market price of silver | oz.     | .62½    | .64½  |
| Silver nitrate                                  | lb.     | .62½    | .64½  |
| Soda ash, 58 per cent, light, flat (bags)       | 100 lb. | 2.00    | 2.12  |
| Soda ash, 58 per cent, dense, flat              | 100 lb. | 3.75    | 3.87  |
| Sodium acetate                                  | lb.     | .30     |       |
| Sodium bicarbonate, domestic                    | lb.     | .01½    | .02½  |
| Sodium bicarbonate, English                     | lb.     | .26     | .27   |
| Sodium bichromate                               | lb.     | .26     | .27   |
| Sodium bisulphate, powd.                        | lb.     | .25     | .25½  |
| Sodium chlorate                                 | lb.     | .37     | .42   |
| Sodium cyanide                                  | lb.     | .17     | .18   |
| Sodium fluoride, commercial                     | lb.     | 2.50    | 3.60  |
| Sodium hyposulphite                             | lb.     | 4.12    | 5.00  |
| Sodium molybdate, per lb. of Mo.                | 100 lb. | .28     | .30   |
| Sodium nitrate, 95 per cent                     | lb.     | .35     | .45   |
| Sodium nitrate                                  | lb.     | .04     | .04½  |
| Sodium peroxide                                 | lb.     | .51½    | .53½  |
| Sodium persulphate, yellow                      | lb.     | .02½    | .03½  |
| Sodium silicate, liquid (60 deg.)               | lb.     | 8.00    |       |
| Sodium sulphide, 30 per cent, crystals          | 100 lb. | .06     | .07   |
| Sodium sulphide, 60 per cent, fused             | 100 lb. | .25     | .26   |
| Sodium sulphite                                 | lb.     | .15     | .16   |
| Sodium sulphate, 98 per cent, drums             | 100 lb. | 4.05    | 3.85  |
| Sulphur, flowers, sublimed                      | ton     | 65.00   | 70.00 |
| Sulphur, crude                                  | lb.     | .18     | .20   |
| Sulphur, 90 per cent                            | lb.     | 1.00    | .29   |
| Tin bichloride, 50 deg.                         | lb.     | 1.28    | 1.10  |
| Tin oxide                                       | lb.     | 1.00    | 1.10  |
| Zinc carbonate                                  | lb.     | .15     | .16   |
| Zinc chloride                                   | lb.     | .15     | .15½  |
| Zinc cyanide                                    | lb.     | Nominal |       |
| Zinc dust, 35 mesh                              | lb.     | .13½    | .14   |
| Zinc oxide, American process XX                 | lb.     | .04½    | .06½  |
| Zinc sulphate                                   | lb.     | .04½    | .06½  |

## Coal Tar Products (Crude)

|                                        |      |               |       |
|----------------------------------------|------|---------------|-------|
| Benzol, pure, water white              | gal. | .23           | .26   |
| Benzol, 90 per cent                    | gal. | .25           |       |
| Toluol, in tank cars                   | gal. | (Fixed Price) | 1.50  |
| Toluol, for non-military use, in drums | gal. | (Fixed Price) | 1.55  |
| Xylo, pure, water white                | gal. | .18           | .20   |
| Solvent naphtha, water white           | gal. | .18           | .28   |
| Solvent naphtha, crude, heavy          | gal. | .12           | .15   |
| Cresote oil, 25 per cent               | gal. | .14           | .55   |
| Dip oil, 20 per cent                   | gal. | .30           | .32   |
| Pitch, various grades                  | ton  | 8.00          | 20.00 |
| Carbolic acid, crude, 95-97 per cent   | lb.  | .05           | 1.10  |
| Carbolic acid, crude, 50 per cent      | lb.  | .35           | .38   |
| Carbolic acid, crude, 25 per cent      | lb.  | .18           | .20   |
| Cresol, U. S. P.                       | lb.  | .18           | .20   |

## Intermediates, Etc.

|                               |     |         |       |
|-------------------------------|-----|---------|-------|
| Alpha naphthol, crude         | lb. | 1.00    | 1.10  |
| Alpha naphthol, distilled     | lb. | 1.00    | 1.10  |
| Alpha naphthylamine           | lb. | .60     | .65   |
| Aniline oil, drums extra      | lb. | .28     | .30   |
| Aniline salts                 | lb. | .40     | .45   |
| Anthracene, 80 per cent       | lb. | Nominal |       |
| Benzaldehyde (f.i.c.)         | lb. | 3.60    | 4.00  |
| Benzidine, base               | lb. | 1.75    | 1.85  |
| Benzidine, sulphate           | lb. | 4.00    | 1.50  |
| Benzonic acid, U. S. P.       | lb. | 3.00    | 3.25  |
| Benzoate of Soda, U. S. P.    | lb. | 2.90    | 3.00  |
| Benzyl chloride               | lb. | 2.45    | 2.50  |
| Beta naphthol benzoate        | lb. | 10.00   | 12.00 |
| Beta naphthol, sublimed       | lb. | .85     | .90   |
| Beta naphthylamine, sublimed  | lb. | 2.65    |       |
| Dichlor benzene               | lb. | .65     | .70   |
| Diethylaniline                | lb. | 4.50    | 5.00  |
| Dinitrobenzol                 | lb. | .36     | .38   |
| Dinitrochlorobenzol           | lb. | .40     | .45   |
| Dinitronaphthalene            | lb. | .50     | .55   |
| Dinitrotoluol                 | lb. | .65     | .75   |
| Dinitrophenol                 | lb. | .55     | .60   |
| Dimethylaniline               | lb. | .70     | .78   |
| Diphenylamine                 | lb. | 1.00    | 1.10  |
| H-anil                        | lb. | 3.00    | 3.25  |
| Metaphenylenediamine          | lb. | 1.85    | 2.05  |
| Monochlorobenzol              | lb. | .65     | .70   |
| Naphthalene, flake            | lb. | .09     | .09½  |
| Naphthalene, balls            | lb. | .10½    | .10½  |
| Naphthionic acid, crude       | lb. | 1.20    | 1.30½ |
| Naphthylamine, sulphonic acid | lb. | 1.00    | 1.10  |
| Nitro naphthalene             | lb. | .45     | .50   |
| Nitro toluol                  | lb. | .55     | .60   |
| Ortho-amidophenol             | lb. | .15     | .18   |
| Ortho-dichlorobenzol          | lb. | .95     | 1.10  |
| Ortho-toluidine               | lb. | .75     | .85   |
| Ortho-nitro-toluol            | lb. | 4.00    | 4.50  |
| Para-amidophenol, base        | lb. | 4.25    | 5.00  |
| Para-amidophenol H. Ch.       | lb. | .15     | .20   |
| Para-dichlorobenzol           | lb. | 1.65    | 1.75  |
| Paranitraniline               | lb. | 1.50    | 1.60  |
| Para-nitro-toluol             | lb. | 3.00    | 3.5   |
| Para-phenylenediamine (base)  | lb. | 2.00    | 2.25  |
| Phthalic acid anhydride       | lb. | 4.00    | 4.50  |
| Phenol, U. S. P.              | lb. | 5.50    | 7.00  |
| Resorcin, technical           | lb. | 8.00    | 9.00  |
| Resorcin, pure                | lb. | .90     | 1.10  |
| Sulphuric acid                | lb. | 1.00    | 2.00  |
| Sulphanilic acid, crude       | lb. | .30     | .32   |
| Tolidin                       | lb. | 2.50    | 3.00  |
| Tolidine-mixture              | lb. | .85     | .90   |

## Petroleum Oils

## Crude (at the Wells)

|                             |      |      |      |
|-----------------------------|------|------|------|
| Pennsylvania.....           | bbl. | 4.00 | —    |
| Corning, Ohio.....          | bbl. | 2.85 | —    |
| Somerset, Ky.....           | bbl. | 2.60 | —    |
| Wester, Ohio.....           | bbl. | 2.28 | —    |
| Indiana.....                | bbl. | 2.42 | —    |
| Illinois.....               | bbl. | 2.25 | —    |
| Oklahoma and Kansas.....    | bbl. | 2.25 | —    |
| Caddo, La., light.....      | bbl. | 2.35 | —    |
| Corsicans, Tex., light..... | bbl. | 1.24 | 1.57 |
| California.....             | bbl. | 1.35 | —    |
| Gulf Coast.....             | bbl. | 1.35 | —    |
| Mexican.....                | bbl. | 1.90 | —    |

## Fuel Oil

|                    |      |      |      |
|--------------------|------|------|------|
| New York.....      | gal. | .12  | —    |
| Pittsburgh.....    | gal. | .071 | .10  |
| Oklahoma-Kans..... | gal. | 1.05 | 2.75 |
| Texas.....         | bbl. | 1.85 | 2.35 |
| Los Angeles.....   | bbl. | 1.60 | —    |
| San Francisco..... | bbl. | 1.60 | —    |

## Gasoline (Wholesale)

|                    |      |      |      |
|--------------------|------|------|------|
| New York.....      | gal. | .24  | .25  |
| Boston.....        | gal. | .25  | .251 |
| Pittsburgh.....    | gal. | .28  | —    |
| Chicago.....       | gal. | .224 | .23  |
| Oklahoma.....      | gal. | .22  | —    |
| San Francisco..... | gal. | .20  | —    |

## Lubricants

|                                                  |      |     |     |
|--------------------------------------------------|------|-----|-----|
| Black, reduced, 29 gravity, 25-30 cold test..... | gal. | .23 | —   |
| Cylinder, light.....                             | gal. | .40 | .42 |
| Cylinder, dark.....                              | gal. | .39 | —   |
| Paraffine, high viscosity.....                   | gal. | .40 | .41 |
| Paraffine, 903 sp. gr.....                       | gal. | .36 | .38 |
| Paraffine, 885 sp. gr.....                       | gal. | .25 | .27 |

## Flotation Oils

(Prices at New York unless otherwise stated)

|                                                                          |      |     |     |
|--------------------------------------------------------------------------|------|-----|-----|
| Pine oil, crude, f. o. b. Florida.....                                   | gal. | .44 | —   |
| Pine oil, steam-distilled, sp. gr. 0.925-0.940.....                      | gal. | .58 | .60 |
| Pine oil, destructively distilled.....                                   | gal. | .35 | —   |
| Pine-tar oil, sp. gr., 1.02-1.035.....                                   | gal. | .42 | —   |
| Pine-tar oil, double refined, sp. gr. 0.965-0.990.....                   | gal. | .42 | —   |
| Pine-tar oil, ref., light, sp. gr. 0.950, tank cars, f. o. b. works..... | gal. | .37 | —   |
| Pine-tar oil, ref., heavy, sp. gr. 1.025, tank cars, f. o. b. works..... | gal. | .28 | —   |
| Pine-tar oil, ref., thin, sp. gr. 1.060-1.080.....                       | gal. | .45 | —   |
| Turpentine, crude, sp. gr. 0.870-0.900.....                              | gal. | .23 | —   |
| Hardwood oil, f. o. b. Michigan, sp. gr. 0.960-0.990.....                | gal. | .23 | —   |
| Hardwood oil, f. o. b. Michigan, sp. gr. 1.06-1.08.....                  | gal. | .31 | —   |
| Wood creosote, ref. f. o. b. Florida.....                                | gal. | .31 | —   |

## Naval Stores

|                                               |          |       |       |
|-----------------------------------------------|----------|-------|-------|
| Rosin A-F barrel.....                         | 280 lb.  | 11.20 | 11.30 |
| Rosin F-I.....                                | 280 lb.  | 11.45 | 11.70 |
| Rosin K-N.....                                | 280 lb.  | 12.50 | 12.70 |
| Rosin W-G-W.....                              | 280 lb.  | 13.00 | 13.10 |
| Spirits of turpentine.....                    | gal.     | .61   | .62   |
| Wood turpentine, steam distilled.....         | gal.     | .63   | —     |
| Wood turpentine, destructively distilled..... | gal.     | .56   | —     |
| Pitch.....                                    | bbl. 200 | 12.50 | —     |
| Tar, kiln dried.....                          | 280 lb.  | 13.50 | —     |
| Retort tar.....                               | gal.     | .62   | —     |
| Rosin oil, first run.....                     | gal.     | .62   | —     |
| Second run.....                               | gal.     | .66   | —     |
| Fourth run.....                               | gal.     | .73   | —     |

## Vegetable Oils

|                               |      |      |      |
|-------------------------------|------|------|------|
| Castor oil.....               | lb.  | .281 | .30  |
| China wood oil.....           | lb.  | .30  | .32  |
| Cocanut oil.....              | lb.  | .18  | .18  |
| Corn oil.....                 | lb.  | .20  | .22  |
| Cottonseed oil, crude.....    | gal. | 1.88 | 1.90 |
| Lined oil, raw, cars.....     | gal. | 1.36 | 1.37 |
| Peanut oil, crude.....        | lb.  | .16  | —    |
| Soya bean oil, Manchuria..... | lb.  | .16  | —    |

## Miscellaneous Materials

|                                          |         |       |       |
|------------------------------------------|---------|-------|-------|
| Barytes, floated, white, foreign.....    | ton     | 38.00 | 42.00 |
| Barytes, floated, white, domestic.....   | ton     | 25.00 | 36.00 |
| Brewers, white, pure.....                | lb.     | .42   | .43   |
| Casoin.....                              | lb.     | .173  | —     |
| Ceylon graphite.....                     | lb.     | .071  | —     |
| Chalk, light, precipitated, English..... | ton     | 20.00 | 25.00 |
| China clay, imported, lump.....          | ton     | 15.00 | 22.50 |
| China clay, domestic, lump.....          | ton     | 8.00  | 12.00 |
| FelDSPar.....                            | ton     | 60.00 | —     |
| Fluorspar, gravel, f. o. b. mines.....   | ton     | 90.00 | —     |
| Fluorspar, washed, powdered.....         | 100 lb. | 1.50  | 2.00  |
| Fuller's earth, powdered.....            | 100 lb. | 1.50  | —     |
| Mexican graphite.....                    | ton     | 75.00 | —     |
| Madagascar graphite.....                 | lb.     | .10   | .15   |
| Ookerite, crude.....                     | lb.     | .35   | .36   |
| Ookerite, American, refined, white.....  | lb.     | .85   | .90   |
| Red lead, dry, carloads.....             | ton     | 1.0   | 1.14  |
| Sopstone.....                            | ton     | 15.00 | 25.00 |
| Talc, American, white.....               | ton     | 20.00 | 40.00 |
| White lead, dry.....                     | lb.     | .094  | .104  |

## Glues

|                                 |      |      |      |
|---------------------------------|------|------|------|
| Extra white.....                | lb.  | .36  | .45  |
| Cabinet.....                    | lb.  | .31  | .40  |
| Brown foot stock.....           | lb.  | .28  | .22  |
| Fish glue, 50-gal. barrels..... | gal. | 1.00 | 1.80 |

## Refractories, Etc.

(F. O. B. Works)

|                                       |          |        |        |
|---------------------------------------|----------|--------|--------|
| Chrome brick.....                     | net ton  | 175.00 | —      |
| Chrome cement.....                    | net ton  | 75.00  | —      |
| Clay brick, 1st quality fireclay..... | per 1000 | 50.00  | 55.00  |
| Clay brick, second quality.....       | per 1000 | 35.00  | 40.00  |
| Magnesite, raw.....                   | ton      | 50.00  | 65.00  |
| Magnesite, calcined, powdered.....    | net ton  | 50.00  | 60.00  |
| Magnesite, dead burned.....           | net ton  | 110.00 | 125.00 |
| Magnesia brick, 9x4 1/2x2 1/2.....    | per 1000 | 50.00  | 60.00  |
| Silica brick.....                     | net ton  | 110.00 | 125.00 |

## Ferrous Alloys

|                                                                            |     |        |        |
|----------------------------------------------------------------------------|-----|--------|--------|
| Ferrocobaltum, 15-18 per cent, carloads, f. o. b. Niagara Falls, N. Y..... | ton | 200.00 | 250.00 |
| Ferrocobaltum.....                                                         | lb. | 15.00  | 30.00  |
| Ferrocobaltum, per lb. of Cr.....                                          | lb. | 250.00 | —      |
| Ferromanganese, domestic, 70 per cent basic.....                           | ton | 325.00 | —      |
| Ferromanganese, English.....                                               | ton | 75.00  | —      |
| Spiegel.....                                                               | ton | 4.00   | 4.50   |
| Ferrosilicon, 75 per cent, f. o. b. Mo.....                                | lb. | 180.00 | 190.00 |
| Ferrosilicon, 75 per cent, f. o. b. N. Y.....                              | ton | 160.00 | 170.00 |
| Ferrosilicon, 50 per cent, carloads, del., Pittsburgh.....                 | ton | 2.35   | 2.40   |
| Ferrotungsten, 75-85 per cent, f. o. b. Pittsburgh.....                    | lb. | 7.50   | —      |
| Ferroumium, f. o. b. works, per lb. of U.....                              | lb. | —      | —      |
| Ferrovandium, f. o. b. works.....                                          | lb. | —      | —      |

## Ores and Semi-finished Products

|                                                                |      |       |        |
|----------------------------------------------------------------|------|-------|--------|
| Antimony ore, per unit.....                                    | ton  | 1.50  | 1.55   |
| Chromite ore, 45 per cent minimum, f. o. b. Cal. per unit..... | ton  | 1.20  | —      |
| Chromite ore, 45 per cent and over, New York, per unit.....    | ton  | 1.20  | —      |
| Manganese ore, 48 per cent and over, per unit.....             | ton  | 80.00 | 100.00 |
| Manganese ore, chemical.....                                   | lb.  | 1.25  | —      |
| Molybdenite, per lb. of MoS <sub>2</sub> .....                 | ton  | 24.00 | —      |
| Tungsten, Scheelite, per unit of WO <sub>3</sub> .....         | ton  | 24.00 | —      |
| Tungsten, Wolframite, per unit of WO <sub>3</sub> .....        | lb.  | 3.25  | 3.60   |
| Uranium oxide, 96%.....                                        | lb.  | 10.50 | —      |
| Vanadium pentoxide, 99%.....                                   | unit | .17   | .17    |
| Pyrites, foreign.....                                          | unit | .28   | .304   |
| Pyrites, domestic.....                                         | unit | .28   | —      |

## Plant Supplies

## BUILDING MATERIALS

|                                              |         |        |        |
|----------------------------------------------|---------|--------|--------|
| Common clay bricks.....                      | M       | 13.00  | 14.00  |
| Hollow tile, 4 x 12 x 12.....                | M       | 170.00 | —      |
| Hollow tile, 12 x 12 x 12.....               | M       | 170.00 | —      |
| Lime.....                                    | ton     | 16.50  | —      |
| Portland cement.....                         | bbl.    | 2.59   | —      |
| Single glass (82-lb.), 10 x 26-16 x 24.....  | ton     | 21.00  | 27.00  |
| Double glass (164 lb.), 10 x 26-16 x 29..... | ton     | 31.00  | 39.00  |
| Yellow pine lumber.....                      | M       | 39.00  | 45.00  |
| Fire lumber.....                             | M       | 38.00  | 53.00  |
| Hemlock.....                                 | M       | 24.50  | 40.00  |
| Tarred felt (14-lb.-sq.).....                | ton     | 14.00  | 22.00  |
| Roofing pitch.....                           | sq.     | 1.30   | 2.50   |
| Asphalt coated roofing (35-55-lb. sq.).....  | sq.     | 1.30   | 2.50   |
| State surfaced asphalt shingles.....         | sq.     | 109.00 | 127.00 |
| Corrugated galvanized iron.....              | 100 lb. | 15.00  | 20.00  |
| Red oxide (Ppte. Copperas).....              | 100 lb. | 3.25   | 8.00   |
| Native red oxide.....                        | 100 lb. | 1.20   | 1.50   |
| Red metallic paint.....                      | 100 lb. | 13.50  | 11.4   |
| White lead in oil.....                       | 100 lb. | 14.00  | 11.84  |
| Red lead in oil.....                         | 100 lb. | 13.00  | 14.50  |
| Zinc oxide (dry).....                        | 100 lb. | 9.00   | 10.00  |
| Zinc oxide—leaded.....                       | 100 lb. | 1.50   | 10.00  |
| Yellow ochre.....                            | 100 lb. | 14.00  | 50.00  |
| Ultra marine blue.....                       | 100 lb. | 135.00 | 150.00 |
| Prussian blue.....                           | 100 lb. | 40.00  | 40.00  |
| Chrome green.....                            | 100 lb. | 43.00  | 49.00  |
| Paris green.....                             | 100 lb. | 1.75   | 2.25   |
| Mineral black.....                           | 100 lb. | 5.50   | 12.00  |
| Powdered bone black.....                     | 100 lb. | 15.00  | 25.00  |
| Lampblack.....                               | 100 lb. | 16.00  | 25.00  |
| Gas carbon.....                              | 100 lb. | 1.00   | 2.00   |
| Mexican petroleum pitch.....                 | 100 lb. | 2.00   | 2.50   |
| Gilsoite.....                                | 100 lb. | 4.00   | 1.00   |
| Coal tar pitch.....                          | 100 lb. | 4.00   | 1.00   |

## STRUCTURAL IRON

|                                        |     |        |        |
|----------------------------------------|-----|--------|--------|
| Blue annealed sheet iron.....          | ton | 84.00  | 89.00  |
| Black sheet iron.....                  | ton | 96.00  | 104.00 |
| Galvanized iron.....                   | ton | 105.00 | 120.00 |
| Galvanized iron.....                   | ton | 150.00 | —      |
| Tern plate, 8-lb. coating.....         | ton | 177.50 | —      |
| Tern plate, 15-lb. coating.....        | ton | 200.00 | —      |
| Tern plate, 25-lb. coating.....        | ton | 240.00 | —      |
| Tern plate, 40-lb. coating.....        | ton | 155.00 | —      |
| Tin plate, prime.....                  | ton | 65.00  | 70.00  |
| Tin plate, 1st.....                    | ton | 60.00  | 65.00  |
| Beams, channels, angles, T's, Z's..... | ton | 92.00  | 105.00 |
| Rivets.....                            | ton | 51.00  | —      |
| Steel pipe, 2 to 3-in.....             | ton | 60.00  | 70.00  |
| Bar iron and steel.....                | ton | 150.00 | 80.00  |
| Chain (1 inch proof coil).....         | ton | 70.00  | —      |
| Nails, bolts, nuts, washers.....       | ton | 300.00 | 500.00 |
| Tool steels, special alloys.....       | ton | 36.60  | —      |
| Bessemer pig iron.....                 | ton | 34.40  | —      |
| No. 2 foundry.....                     | ton | 47.50  | —      |
| Steel billets (4 x 4).....             | ton | —      | —      |

## POWER HOUSE SUPPLIES

|                                   |     |      |      |
|-----------------------------------|-----|------|------|
| Steam packing, rubber duck.....   | lb. | .99  | 1.10 |
| Asbestos, high pressure.....      | lb. | 1.76 | —    |
| Asbestos, wired.....              | lb. | 1.30 | —    |
| Asbestos, graphited brand.....    | lb. | 1.21 | —    |
| Asbestos, white.....              | lb. | .75  | —    |
| Rubber, sheet.....                | lb. | .07  | —    |
| Cup grease.....                   | lb. | .07  | —    |
| Transmission grease.....          | lb. | .04  | —    |
| Axle grease.....                  | lb. | .04  | —    |
| Gear grease.....                  | lb. | .04  | .13  |
| Cotton waste.....                 | lb. | .73  | —    |
| Hose, underwriters, 2 1/2 in..... | ft. | .30  | —    |
| Hose, air, 1 in.....              | ft. | .30  | —    |



# INDUSTRIAL

## Financial, Construction and Manufacturers' News

### Construction and Operation

#### Alabama

**FLORENCE**.—The city will enlarge its filtration plant. Estimated cost, \$175,000. Address the Mayor.

#### Arkansas

**BIERNE**.—J. A. Schofield, Warren, Pa., is interested in a plan to build a factory for the manufacture of wood alcohol and other chemicals.

#### California

**STOCKTON**.—The Wagner Leather Co. will rebuild its tannery recently destroyed by fire. The new building will be four story, of brick construction.

#### Connecticut

**HARTFORD**.—Henry Souther Engineering Co., 11 Laurel St., will build a 35 x 35 ft. brick addition to its laboratory. Estimated cost, \$15,000. Ford, Buck & Sheldon, 60 Prospect St., architects.

**WALLINGFORD**.—R. Wallace & Sons has awarded the contract for the construction of a 3-story, 50 x 120 ft. brick factory for the manufacture of silver, to C. P. Wooding, Jr., Wallace Ave. Estimated cost, \$50,000.

#### Florida

**JACKSONVILLE**.—The American Chemical Co., 35 East Forty-first St., New York City, will rebuild its fertilizer plant here destroyed by fire entailing a loss of \$1,000,000.

**MANATEE**.—The Sea Products Co., 1537 Chestnut St., Philadelphia, Pa., will build a factory here for the manufacture of fish leather, oil, fertilizer and etc.

#### Georgia

**COLUMBUS**.—The Union Seed & Fertilizer Co. will build a plant for the manufacture of peanut oil.

#### Illinois

**WAUKEGAN**.—The Griss-Pfleger Tanning Co. is building a 140 x 170 ft. hide house addition to its plant.

#### Indiana

**HAMMOND**.—The International Wood Products & Chemical Co., recently organized, with a capital stock of \$100,000, will operate plants in Canada and Tennessee and will also open a school of Chemical Research and be advisors to those who desire to enter the chemical field. Frank A. Gross, 376 Indiana Ave., secretary and treasurer.

**KOKOMO**.—The Kokomo Rubber Co. is building a 2-story plant on South Main St. Estimated cost, \$25,000.

#### Iowa

**CLINTON**.—The Klein Paper Co., Nineteenth Ave. and Fifth St., will build a paper mill and power plant. Estimated cost, \$175,000. J. Morrell, 410 Howes Bldg., architect.

#### Kansas

**HARRISON**.—H. W. Rodus will remove and remodel his 200-ton concentration plant known as the Texas Mill, and is in the market for sludge and slime tables, mill roofing, mill hardware, belts, drills, pipes, ore cars and track. Estimated cost, \$35,000. H. W. Rodus, manager.

**HUTCHINSON**.—The Morton Salt Co., 80 East Jackson Blvd., Chicago, Ill., will build a salt plant here, main building, three story, 50 x 140 ft. F. V. Parkins, 7524 Stewart Ave., Chicago, architect.

**MONARCH**.—The Commerce Mining & Royalty Co., Commerce, Okla., has awarded the contract for the construction of a 250-ton concentration plant to Elmer Stevens, Miami, Okla. Estimated cost, \$65,000.

**TREECE**.—The Eloosa Lead & Zinc Co. will build a 300-ton concentration plant and is in the market for sludge and slime tables,

drills, roofing, mill hardware, engine, boilers, jigs, air compressors, belts, pipe, track, cars, and ore cans. Estimated cost, \$65,000.

**TREECE**.—The Lawyers Mining Co. will build a 250-ton concentration plant and is in the market for sludge and slime tables, boiler, roofing, mill hardware, crushers, rollers, drills, ore cars, track and air compressors. Estimated cost, \$65,000. George O. Pearson, superintendent.

#### Kentucky

**COVINGTON**.—The Kelley-Koett Co. has purchased a site on West Fourth St. and will build an addition to its plant for the manufacture of X-ray machines.

#### Louisiana

**NEW ORLEANS**.—The Beners Salt Co., Inc., will open a salt mine near Anse La Butte, and is in the market for mine hoists, screens, crushers, mills, etc. R. A. Shelton, superintendent in charge.

#### Maryland

**BALTIMORE**.—The American Can Co., Maryland Trust Building, has awarded the contract for the construction of a 4-story, 38 x 140 x 176 ft., can factory on Boston and Hudson Sts., to West Construction Co., 907 American Building. Estimated cost, \$150,000. Noted July 15.

**BALTIMORE**.—J. T. Lewis Bros. Co., 1015-19 East Fayette St., has awarded the contract for the construction of a plant to include several 1- and 2-story factory buildings of various sizes, on Columbia Ave., for the manufacture of ammunition, to McVey Construction Co., Law Building.

**HUTTON**.—The Tiera Tanning Co. will build an addition to its plant. Estimated cost, \$18,000.

#### Massachusetts

**MILFORD**.—The city has awarded the contract for the construction of a sewage disposal plant, to Cenedella & Co., 68 School St.

#### Michigan

**DETROIT**.—The American By-Products & Chemical Co., 1111 Woodward St., has awarded the contract for the construction of an addition to its factory at Jefferson and Clark Aves., to L. W. Zander, 708 Fourteenth St.

**GRAND RAPIDS**.—Semet-Solvay Co., Milton Ave., Syracuse, N. Y., will build a 1- and 2-story, reinforced concrete, brick and steel picric acid plant here. Estimated cost, \$2,000,000. H. N. Cole, c/o Owners, engineer.

**SAGINAW**.—The Saginaw Malleable Iron Co. will build an addition to its plant.

**WYANDOTTE**.—The city plans to build a filtration plant of 4,000,000 gal. capacity. Estimated cost, \$175,000. W. C. Lambert, Mayor.

#### Mississippi

**PASCAGOULA**.—The city will build sanitary sewage and a disposal plant. Estimated cost, \$100,000. X. A. Kramer, May-nolia, engineer.

#### Missouri

**KANSAS CITY**.—The Zahner Manufacturing Co., 12 West Tenth St., will rebuild its plant for the manufacture of galvanized iron, recently destroyed by fire entailing a loss of \$15,000.

**ST. LOUIS**.—The American Paper Products Co. has awarded the contract for the remodeling of its plant, to J. H. Bright Contracting & Building Co., St. Louis. Estimated cost, \$3,000.

**ST. LOUIS**.—Charles L. Holman, President of Laclede Gas Light Co., has announced that procurement orders have been issued by Procurement Bureau of the Ordnance Division for the construction of two shell loading plants. One plant is to be located near Broadway just south of River des Peres, and is to be 1200 ft. long and 200 ft. wide, one story, except in center, which will be heat treating section and have a height of two or three stories, to be used for the manufacture of 155 mm. shells. Another plant will be located near plant of Scullin Steel Co. on Manchester

Ave., where 94-in. shells will be manufactured. Estimated cost of buildings and equipment \$8,000,000, which will be financed by Government and operated by gas company.

**ST. LOUIS**.—The Johnson Tin Foil & Metal Co., 6020 South Broadway, has awarded the contract for the construction of a 2-story, 80 x 170 ft. factory, to Murch Bros., Railway Exchange Building. Estimated cost, \$30,000.

**ST. LOUIS**.—The Mallinckrodt Chemical Co., 3600 North Second St., will build a 60 x 100 ft. factory for the manufacture of ether, on Second and Mallinckrodt. Estimated cost, \$25,000. A. H. Haeseler, Wainwright Building, architect.

#### Nebraska

**MERRIMAN**.—The Wyoming-Montana Co., Riverton, Wyo., has awarded the contract for the construction of a potash reduction plant here, to W. Berg Co., First National Bank Building, Omaha. Estimated cost, \$300,000.

#### New Jersey

**BRIDGETON**.—The city will build a sewage disposal plant. Estimated cost, \$3,500. W. D. Frederick, engineer.

**BRIDGETON**.—The Cumberland Glass Manufacturing Co. will build a 1-story, addition to its plant on North Laurel St. Estimated cost, \$10,000.

**CAMDEN**.—The Public Service Gas Co., 80 Park Ave., Newark, has awarded the contract for the construction of a 2-story, 36 x 78 ft. generator building and a 2-story, 29 x 43 ft. brick and brick shale reinforced concrete and brick, on Second and Cherry Sts., to Mockett Construction Co., Sixth and Market Sts. Estimated cost, \$23,000 and \$20,000 respectively.

**HARRISON**.—The Crucible Steel Co., Grant Ave., Jersey City, will build an 81 x 180 ft. brick and steel gas reduction plant on Cape May St. Estimated cost, \$85,000.

**NEWARK**.—The Atlas Refining Co., Lockwood St., is building a 2-story, 40 x 61 ft. brick oil compounding house. Estimated cost, \$15,000. Gray & Ring, architects.

**NEWARK**.—The Dye-Products & Chemical Co., 187 Pommer Ave., will build a plant on Vandevor Ave.

**PASSAIC**.—The Manhattan Rubber Co., Willett St., has awarded the contract for the construction of a 60 x 208 ft. addition to its plant to Austin Co., 16112 Euclid Ave., Cleveland, O.

**RUTHERFORD**.—The Alliance Silk Co., 180 East Seventh St., Paterson, has awarded the contract for the construction of a 4-story, concrete and brick shoe and dye mill, to J. J. Leary Construction Co., Passaic. Estimated cost, \$50,000.

#### New York

**ALBANY**.—The Patent Vulcanite Roofing Co., Tivoli St., will build a 1-story, 70 x 245 ft. factory. Estimated cost, \$35,000.

**BUFFALO**.—The Contact Process Co., Abbott Road, has awarded the contract for the construction of a 1-story, reinforced concrete, brick and steel addition to its plant, to J. Cowper Co., Inc., Buffalo. Estimated cost, \$13,500.

**LONG ISLAND CITY**.—The Ravenswood Paper Mills Co. will build a 1-story, 70 ft. addition to its plant here. Estimated cost, \$10,000.

**NIAGARA FALLS**.—The Niagara Electric Chemical Co. will build a 2-story, 25 x 224 ft. reinforced concrete, brick and steel, factory on Buffalo Ave. Estimated cost, \$50,000.

**ROCHESTER**.—The Taylor Instrument Co., 95 Adams St., has awarded the contract for the construction of a three story, 100 x 230 ft. brick and mill construction factory for the manufacture of thermometers, to Corsling & Swan Construction Co., 243 Powers Building.

#### Ohio

**CANTON**.—The city will build a sewage disposal plant including three additional Imhoff tanks, enlarging sludge beds, installing incinerator and laboratory. Estimated cost, \$50,000. W. E. Sarver, City Hall, engineer.

**CINCINNATI**.—The Nitrate Division, War Department, Washington, D. C., has awarded the contract for the construction of a nitrate plant, to the DuPont Co., Munsey Building, Washington, D. C. Cost will run into millions.

**CINCINNATI**.—The Peters Cartridge Co., First National Bank Building, has taken over the plant of the Le Blond Machine Tool Co. and is in the market for equipment for use in the manufacture of munitions.

**CLEVELAND.**—The Electric Products Co. will build a one story, 90 x 176 factory. Estimated cost, \$30,000.

**CLEVELAND.**—The Lennox Chemical Co., 1201 East 15th St., will build a one story, 90 x 400 ft., brick and steel factory.

**CLEVELAND.**—The Phoenix Oil Co., 2554 West Fifth St., has purchased a site on Perry Ave. and will build a factory. Estimated cost, \$60,000.

**TOLEDO.**—The Doehler Die Castings Co., manufacturers of hand grenades, depth bombs, and parts of gas masks, will build a one story, 60 ft. addition to its foundry and a two story, 50 x 150 ft. factory on Smead Ave. and the Lake Shore R. R.

**WARREN.**—The Gregory Rubber Co., 144 North Union Ave., Akron, will build a plant here, the main unit of which will be a two story, 50 x 100 ft. factory. Stalker & Hemp, 706 Western Reserve Bank Building, local representatives.

### Oklahoma

**CARDIN.**—The Healdton Mining Co. will build a 200-ton concentration plant and is in the market for sludge and slime tables, crushers, cars, track, engine, belts, mill hardware, roofing, mill lumber and air compressors. Estimated cost, \$65,000.

**MONARCH.**—The Miami Royal Mining Co., Miami, will build a 300-ton concentration plant and is in the market for sludge and slime tables, mill hardware, lumber, crushers, air compressors, drills, tubes, pipes, conveyors, engines and boilers. Estimated cost, \$65,000.

**PAWBUKA.**—The city plans to build filtration plant, Archer & Stevens, New England Bank Bldg., Kansas City, Mo., engineers.

**QUAPAW.**—The Alamo Lead & Zinc Co. will build a 200-ton concentration plant and is in the market for sludge and slime tables, engine, boiler, lumber, roofing, air compressors, fans, drills, belts, mill hardware, crushers, track, ore cars and conveyors. Estimated cost, \$30,000. J. T. Burgher, Dallas, Texas, superintendent.

**ST. LOUIS.**—The Huttig Lead & Zinc Co., 328 Frisco Building, Joplin, Mo., will rebuild its 200-ton concentration plant and is in the market for sludge and slime tables, engine, boiler, lumber, roofing, air compressors, drills, belts, track, ore cars, crushers, slime and sludge tables, engine, boilers, pipes, scales, acid roofing. Estimated cost, \$70,000. R. M. Simrall, superintendent.

### Oregon

**PORTLAND.**—The Viking Marine Paint Co., Sherlock Bldg., has awarded the contract for building a one story, 40 x 70 ft. reinforced concrete, brick and steel factory on Industrial Center, to Rasmussen-Grace Co., 180 Burnside St. Estimated cost, \$12,500.

### Pennsylvania

**BEAVER FALLS.** The Meltrup Steel Products Co. has purchased the plant of the Pittsburgh Steel Co. and will convert same into a producing plant for its own use.

**CORNWELLS.** The Badenhausen Boiler Co. will build a one story, 195 x 345 and 200 x 350 ft. machine shop and manufacturing plant. Estimated cost, \$300,000.

**MT. UNION.**—The Aetna Explosive Co., Inc., 120 Broadway, New York City, is rebuilding its factory here, including new buildings, which were recently destroyed by fire. Estimated cost, \$200,000.

**PHILADELPHIA.**—The E. G. Budd Manufacturing Co., Twenty-fifth and Huntington Sts., has awarded the contract for the construction of a one story, 70 x 145 ft., brick, steel piling plant to Barclay, White Co., 1713 Sansom St. Estimated cost, \$25,000.

**PHILADELPHIA.**—The Dermatological Research Co., Lightner and Naundine Sts., will build a three story, concrete and brick medical research building. Estimated cost, \$15,000. J. C. Piedstein, Penfield Building, engineer.

**PHILADELPHIA.**—McNeely 1732 North Randolph St. has awarded the contract for the construction of a three story, 8 x 13 ft. addition to its factory for the manufacture of glass and to Stewart Bros., 2238 North Orkney St. Estimated cost, \$5000.

**PITTSBURGH.**—The Jones & Loughlin Steel Co. will build a one story, hydroproduct coking plant. Estimated cost, \$4,000.

### Rhode Island

**WOONSOCKET.**—The Electric Dye Works, 229 Perry Ave., has awarded the contract for the construction of a two story, 72 x 88 ft. plant.

### South Carolina

**CHARLESTON.**—The Charleston Heights Corporation, 272 Meeting St., has awarded the contract for the construction of a sewage disposal plant to McGrady Bros. & Cheves.

**GREENVILLE.**—The Empire Rubber Manufacturing Co. will build a plant for the manufacture of rubber shoes, canning rubbers and other products.

### Tennessee

**ASBURY.**—The Knoxville Lime, Sand & Transportation Co., Knoxville, Tenn., will rebuild its lime plant recently destroyed by fire entailing a loss of \$6000.

### Texas

**HOUSTON.**—The Universal Tire & Rubber Co. has awarded the contract for the construction of a 100 x 200 ft., reinforced-concrete and steel plant. Estimated cost, \$100,000.

**PORT NECHES.**—G. D. Anderson, 2215 Calder St., Beaumont, has purchased a 672 acre site on Neches River and will build an oil refinery.

### Virginia

**HAMPTON.**—The Bureau of Yards and Dockways Department, Washington, D. C., has awarded the contract for the construction of an addition to the White Gray at the Naval Operating Base, to Wilson, Rie & Company, American Bank Building, Norfolk. Estimated cost, \$17,800.

### West Virginia

**WESTON.**—The city will build a sewage disposal plant. Estimated cost, \$15,000.

### Wisconsin

**STEVENS POINT.**—G. W. Mead will build a one and two story, 100 x 400 ft. mill for the manufacture of tissue paper. Estimated cost between \$25,000 and \$50,000. L. A. DeGuere, Stevens Point, engr.

### Canada

#### British Columbia

**BURNABY.**—The Burnaby Oil Co. will build a plant here. Estimated cost, \$100,000.

#### Ontario

**KITCHENER.**—The Canadian Consolidated Rubber Co., 137 King St., will build an addition to its factory. Estimated cost, \$10,000. A. C. Copeland, engineer.

**TORONTO.**—W. Harris & Co., Danforth Ave., has purchased a site on the Ashbridges Bay Industrial site and will build a plant for the manufacture of glue. Estimated cost, \$100,000.

#### Quebec

**DRUMMONDVILLE.**—The Drummondville Match Co. has awarded the contract for the construction of a factory to J. A. Nadeau. Estimated cost, \$100,000.

**WINDSOR MILLS.**—The Canadian Explosives, Ltd., 120 St. James St., Montreal, will rebuild its plant which was totally destroyed by fire entailing a loss of \$60,000.

## Industrial Notes

**THE TOLEDO FURNACE CO.** is producing gas from its coke oven plant which is being used by a number of industrial plants at Toledo, Ohio.

**THE TOLEDO RAILWAY AND CO.** has purchased an 18-acre site at Seven Thomas meters built by the Cutler-Hammer Mfg. Co., Milwaukee, are in use for measuring it.

**THE H. KOPPERS CO.,** Pittsburgh, Pa., erected and placed in operation sixty coke ovens at the plant of the Bethlehem Steel Corporation, which makes a total of 180 ovens in operation.

**THE WESTERN STEEL CAR AND FOUNDRY CO.** at Hegewisch, Chicago, Ill., has installed two single-phase Snyder electric furnaces, to be operated together on a polyphase current system. These two furnaces were built by the Industrial Electric Furnace Company, Chicago, Ill., and are each of one and one-half tons capacity. They are designed for acid operation on steel castings, and unusually good results are expected from this method of operating single-phase furnaces on a polyphase system.

**THE FAULKNER COMPANY,** Rochester, N. Y., has appointed Lawrence C. Stahlbrodt to take charge of its publicity department. Mr. Stahlbrodt was originally educated in chemistry but has been engaged for the past six years in publicity work. He was last connected with The Hurst Engraving Company of Rochester.

**THE CUTLER-HAMMER MANUFACTURING CO.,** Milwaukee, Wis., manufacturers of electric controlling devices, held their eleventh annual picnic under the direction of the employees' activities committee at Waukegan, Ill., near Lake Michigan, July 27. A program of athletic events for boys and girls, both young and old, was provided; prizes consisting of various amounts of money. A large number of employees attended with their families.

**LAW AND COMPANY,** Consulting Chemists, for the past fifteen years, known as Picard-Law Company, have moved their Atlanta (Ga.) laboratories to larger quarters in the Walton Building. The company shall continue their oil, mill and fertilizer specialties and wish to announce that they are especially equipped to deal with problems in connection with Georgia mineral developments, especially kaolin, fuller's earth, hauxite and pyrites.

**GENERAL CHEMICAL COMPANY** reports that the period of six months ended June 30, 1918, showed total profits of \$5,250,468, as compared with \$5,558,938 for the same period one year ago. The balance available for dividends amounted to \$5,262,468, a decrease of \$146,470, and the balance for common dividends after payment of the usual preferred dividends was equivalent to \$29.00 a share for the six-month period, as compared with \$29.10 a share for the same period a year ago.

The sum of \$2,000,000 was written off for depreciation as compared with half that amount for 1917.

**THE CASE MANUFACTURING CORPORATION,** Denver, Colo., announces that Mrs. W. W. Case, Sr., Fred McL. Strout, Theodore W. Muckle and Seth Parlin, all formerly of the Denver Fire Clay Co., have organized a new company to manufacture oil burners and oil furnaces which were invented and perfected by the late W. W. Case, Sr., former president of the Denver Fire Clay Company.

**THE ASPROMET COMPANY,** Pittsburgh, Pa., announce the opening of a Washington, D. C. office in the Munsey Building, Mr. O. C. Robinson, president of the district manager and the office will also be under the personal supervision of Mr. H. E. Marks, general sales manager.

**THE BETHLEHEM STEEL CO.,** Steelton, Pa., has recently put in operation a new battery of 50 Koppers by-product coke ovens. The H. Koppers Co., of Pittsburgh, began the construction work in November, 1916. The ovens have an individual capacity of 123 tons each with a combined output of 700 new tons of coke per day in 18 hours coking time, or 1000 tons on a 24-hour basis.

**THE THOMAS FURNACE & IRON CO.,** Easton, Pa., is planning to put its Heltetown furnace in full operation very shortly.

## Manufacturers' Catalogs

**THE UNITED FILTERS CORPORATION,** Salt Lake City, Utah: Bulletin No. 103 on the Sweetland filter, laboratory trunnion type, designed especially for the use of small scale development work, research laboratories, industrial and college laboratories, etc. This pamphlet also gives a suggested arrangement for installing the Sweetland laboratory trunnion filter, operation, and special features of operation.

**THE H. KOPPERS CO.,** Pittsburgh, Pa., has issued a little pamphlet on Nonpareil insulating brick for furnaces and ovens which they will be glad to distribute to anyone who charges on request.

**THE WORTHINGTON PUMP AND MACHINE CORPORATION,** 115 Broadway, New York: Deane Bulletin D-702, May, 1918, describing vertical triplex power pumps, single and double acting, and a 56-page bulletin and is well illustrated.

**THE CUTLER-HAMMER MANUFACTURING CO.,** Milwaukee, Wis.: Booklet A, June, 1918, on motor-operated brakes for alternating current service.

**THE WATERBURY LUMBER CO.,** 173 Milk Street, Boston, Mass., have on hand a number of reprints of Mr. F. E. Lieben-thaler's article on "Intensive Toluol Production" which will be glad to supply to anyone interested.

**THE WELLMAN-SKEWER-MORGAN COMPANY,** East 70th St. and Central Ave., Cleveland, Ohio, Bulletin No. 10, dated July, 1918, on W-34 coke oven, its construction, and illustrating some of its installations.

**THE BROWN INSTRUMENT COMPANY,** Philadelphia, Pa.: An 80-page catalog describing the line of Brown instruments and recording instruments and high-temperature measuring instruments. A copy will be sent on application to anyone interested.



# CHEMICAL & METALLURGICAL ENGINEERING

A consolidation of ELECTROCHEMICAL & METALLURGICAL INDUSTRY and IRON & STEEL MAGAZINE

## MCGRAW-HILL COMPANY, INC.

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## Fourth Liberty Loan

### To Be a Victory Loan

NEXT month the Government will call upon us to support the fourth great loan to aid in winning the war, and the opportunity to help should be acclaimed with joy by every loyal American. If pride in the achievement of our troops is ever to find expression, and if we are determined to see that their sacrifices have not been made in vain, now is the time to act. The nearer we approach the day of victory, the greater the necessity for unwavering support of our cause. Thus the coming loan will be a real test of loyalty and confidence.

We want to be able to look every returning soldier squarely in the eye and feel that we matched his service with our dollars. Over one and one-half million of our troops are now abroad, and if they need billions of dollars to furnish them food and munitions they should but have to make their needs known to have them supplied. The issue of bonds for the fourth loan probably will equal or exceed six billions of dollars. Taxation will account for another eight billions, but if our war program for the fiscal year ending June 30, 1919, calls for twenty-four billions we will still have some money to raise.

These sums should not stagger us, for they are but a fraction of our national resources which, as Thomas W. Lamont recently pointed out, were estimated at the beginning of the war at \$250,000,000,000. The total sum derived from Government securities to date is but \$9,978,785,000, so that we still have plenty of reserve. When the fourth loan is called for on September 28, let us make our subscriptions part of the day's business and return to our task of winning the war as speedily as possible.

## Distinguishing Between Essentials and Non-Essentials

ONE of the clearest recollections of our "prep" days in chemistry is the wise injunction given by an excellent teacher, to "learn to distinguish between essentials and non-essentials." Specially applicable to the study of science and the cultivation of keen observation, the lesson is useful wherever efficiency is paramount, whether it be in the conduct of a government at war or in the pursuit of our usual vocations.

Early in our participation in the war a great deal was said about essential and non-essential industries, and there was much speculation as to how such classification could be made. Obviously a hard and fast line could not be drawn, and we believe there would have been less confusion and misunderstanding if it had



been made plain that the essentiality of different industries in war time is a relative matter and that conditions were likely to change as time went on. Emphasis should have been laid on the fact that different lines of business were *more or less* essential to the winning of the war, and that the classification was certain to change from time to time.

With accumulated experience we have adjusted ourselves to the rulings of the War Industries Board because we have recognized the necessity of centralizing control in one body; also we have been impressed with the sanity of most of the Board's rulings. Furthermore, the spirit of pessimism which earlier prevailed on account of the fear that the list of essential industries would become more and more restricted, may now give way to optimism over the fact that the list is actually expanding. The War Industries Board is formulating a new list of "preferred" industries, which will be about twice as long as the one issued last April containing thirty-two classes. War needs have actually expanded, and civilian demands also have pressed for relief.

The preference list will be a key to the relative importance of the country's manifold industries. That it will be fair and based on sound judgment is assured from the fact that the values are determined by surveys of national needs. Once established, the list will be maintained by a system of priority in determining the use of the six basic elements of industry which are: material, facilities, fuel, transportation, labor and capital.

The publication of the new list will do more than determine the relative essentiality of different lines of business: it will draw a line for the enforcement of the work-or-fight ruling of the War Department. Men, otherwise exempt, who are engaged in any of the preferred industries will be regarded as engaged in war work, and therefore contributing as much to the winning of the war as though they were fighting. It looks as though we are distinguishing quite clearly between essentials and non-essentials.

### Chemical Exposition to Be Held This Month

RUMOR has been rife to the effect that the Fourth National Exposition of Chemical Industries would have to be abandoned because the Government had requisitioned Grand Central Palace for a base hospital. We are glad to be able to announce that, although the Palace is to be taken over by the Government, the plan will not interfere with the holding of the Exposition as planned for the week of September 23. Mr. Alfred I. duPont, owner of the leasehold on Grand Central Palace, recently announced that he had met the Government's request for the building and had notified tenants to vacate by September 15. At the same time it was made known that the Government would not require that portion of the building used for the exposition until October 1, by which time the exhibits could be removed. Meanwhile plans that have been under way for almost a year indicate that the exposition will be larger and better than ever, and will fittingly represent the industry which is growing so rapidly.

### Chemistry in Modern Warfare

THE reader will find much of interest and suggestion in the article, published elsewhere in this issue, describing the phenomenal growth of the Chemical Warfare Service, National Army. The title of the Service itself is a tribute to the importance of the science and a recognition of the extent to which chemists have been called to the colors. History records the stink-pot of the Chinese as a device for gas warfare, but we have no previous knowledge of a corps of eminent chemists engaged in research to discover the most effective gases for rendering an adversary *hors de combat*; nor of large factories devoted to the making of the said gases; nor of shell-filling stations where missiles are charged with the deadly stuff. All this has been reserved for the year of grace 1918 when the more civilized nations of the earth are trying to annihilate Hohenzollernism with its own diabolical devices.

Little has been said in public about our work in gas warfare because secrecy is essential to success. The strategic value of gas warfare lies in the element of surprise. If the enemy can be caught without protection against a new gas, its use will prove effective until he can determine its nature and provide means for nullifying its action. Once he has succeeded in developing defensive measures, further attacks with that particular gas may not prove very effective. Hence the impossibility of publishing the results of the research in gas offense. This, however, need not prevent a full knowledge on the part of the chemical profession of the magnificent work which its members are doing in the present war. The commissioned personnel is practically a list of chemical leaders in the United States.

### Germany's Finger in the Platinum Pie

OUR editorial under this caption in our last issue has evoked letters of protest from Charles Engelhard and Baker & Co., Inc., which we are glad to accord space in the columns regularly devoted to the views and comments of our readers.

### Gold Mining An Essential Industry

THE Priorities Board of the War Industries Board has formally resolved that gold mining is an essential war industry, and as such is entitled to certain preferential treatment. Accordingly the powers of the Board will be exercised to see that gold mines get tools, machinery, equipment, transportation service, fuel and labor.

Of course the War Industries Board is not responsible for the predicament of gold mining, neither can it alleviate its sufferings by resolution, although the latter will obviate the cost of delays which are often serious. The gold mining industry needs something more than resolutions or even fuel, labor and supplies. It needs these things at normal cost or else an enhanced value of its product. Since the latter is not likely to materialize, the next form of assistance which suggests itself is the bonus. The closer the cost of producing gold approaches \$20.67 per ounce, the sooner we will

have to choose between supporting the industry or seeing it languish and die.

At the beginning of the war we pointed out the economic advantage accruing to the Allies from the fact that they controlled the production of gold. Great Britain alone controls 60 per cent of the world's output, and the Allies today control well over 90 per cent. If this item is an advantage now, it must prove even more effective after the war. And if we expect to retain that advantage in the face of a decreasing production of gold we must take measures for support of the industry.

Gold production is falling off, the world over. Transvaal production for May 1918 was only 741,317 fine ounces compared with 779,385 fine ounces in May, 1917. United States production has declined from a value of \$101,000,000 in 1915 to \$84,000,000 in 1917.

Gold producers in the United States recently met at Reno, Nevada to consider what should be done to avert collapse of the industry. It is quite evident from reports of the meeting that sanity and good judgment prevailed. The assembly expressed the frank opinion that, without assistance, gold mining is likely to fall off alarmingly in this country. Government relief for producers to correspond with the increased cost of production was held to be a necessity, but any thought of altering the value of gold or disturbing our financial system was deprecated. Sound money was recognized as absolutely essential even if gold mines have to close for a time.

### Iron Contents Of Iron Ores

THE fact that iron industries throughout the world thrive under quite divergent conditions suggests that there are compensations. Industries that are well fixed in some respects are not nearly so well fixed in others. If it were otherwise, the competitive condition could hardly be maintained as well as it has been.

Thus one observes that Sweden has large reserves of iron ore of exceptional purity, practically the plain oxide, but some of the ores lie within the Arctic Circle, and there is no fuel except charcoal and "white coal" which lately has been applied to advantage. Sweden has iron-producing companies that have been in continuous existence for several centuries. Then there is the very low iron content of the Minette ores of Lorraine, but by admixture a self-fluxing charge can be made. Great Britain supports an iron industry with both classes, extremely lean native ores and very rich ores brought from Spain. India, China and Japan have certain advantages and disadvantages, and if they had an even start with Great Britain or even the United States, they would now have flourishing iron industries of very considerable size.

In each of these cases there is a mixture of advantages and disadvantages and so each has a place as an iron producer and, except in the case of Sweden, as a steel producer of corresponding size. Here in the United States we have had a situation which has been frequently looked upon as follows: In the South and in Virginia we have rather lean ores which on account of their close association with coal and limestone deposits can be worked to advantage and the product

shipped very considerable distances. Also we have the rich Lake Superior deposits, not associated with coal or limestone, which on account of their richness can be transported great distances, say a thousand miles, for smelting. Then, not to mention various smaller districts, we have the Atlantic seaboard, which can bring rich ores from Cuba and Chile and on occasion from Sweden, and not absolutely barred from using Lake Superior ore.

This is, perhaps, the common picture, but as to the Lake Superior ores it is based partly upon conditions that have been slipping away for well nigh two decades. That is a fact that must be faced by the heads of producing concerns using Lake Superior ores and also by those who contemplate establishing new plants dependent upon those ores. From time to time decisions must be made by the captains of industry having regard to the analysis and physical properties of the Lake Superior iron ores available.

To metallurgical and mechanical engineers it is a fact that must be present all the time and must affect practically the daily work. The development of each of the Lake Superior ranges was predicated upon iron contents, natural state, well up in the sixties. There remains some rich ore, but not nearly as much as formerly, and with the quintupling of the production in a double decade the mass of rich ore has been so greatly diluted that it hardly makes an impress in the final reckoning. That reckoning is compiled annually by the Lake Superior Iron Ore Association, whose latest report shows that the average iron content of the 62,616,045 gross tons of iron ore shipped from the Lake Superior region in 1917 was 51.3812 per cent, natural state, as shipped. That is many units removed from the iron content that made the Lake Superior region famous. To put the matter flatly, if until this date the Lake Superior region had been shut off from human ken, and we had our present iron-producing districts, Alabama, Virginia, Atlantic seaboard etc., and suddenly these 51 per cent Lake Superior ores were offered, there would be no great rush to build an iron and steel industry upon them.

The industry, however, is strong, vigorous and growing. The credit must be given not to Nature but to the mechanical and metallurgical engineers, to their steam shovels which were handling more overburden or ore per shovel than those whose achievements in digging the Panama Canal attracted world-wide attention, to the wonderful Lake carriers receiving and discharging in a very few hours burdens running into five figures, to the automatic appliances at 600-ton blast furnaces, to all the metallurgical and mechanical devices used in converting Lake Superior ores into finished steel products. The average content of Lake ores shipped has been declining at the rate of about one unit in every three or four years and there is no reason to expect that the decline will not continue, though probably at a somewhat lower rate in future. This decline is going to keep the engineers busy if the industry based upon Lake Superior iron ore is to continue to grow in decades to come, or even to maintain its present tonnage. The industry cannot rest with the methods and appliances it has now. Year by year improvements must be made to compensate for declining iron units in an ore that must often travel more than a thousand miles.

## Readers' Views and Comments

### Need of Optical Instruments in Industrial Laboratories

*To the Editor of Chemical & Metallurgical Engineering*

SIR:—A few days ago the writer learned from the chief chemist of a well known packing house, that at this time they are in need of a number of refractometers.

Now I can recall at least three well known physics laboratories that are in possession of at least one good refractometer each, and moreover I am quite certain that these instruments are not in constant use.

It seems to me, therefore, that some definite relation should exist between these laboratories and the essential industries. Not only should this apply to refractometers but to other optical instruments that are difficult to obtain just now. With our small classes and no research work many polariscopes, colorimeters, optical pyrometers, etc., might be turned over to the industries for the duration of the war.

Personally, I see no reason whatever why the Government might not ask for a list of all such instruments from the physics laboratories of the country, in order that, should it seem desirable, these instruments may be called for so that the industries might have the use of them.

Practically all of them were brought into this country duty-free, so that the industries could afford to buy them from colleges at the prices they paid for them and the colleges would thereby lose nothing.

Again they could, to be sure, be loaned for the period of the war.

G. A. SHOOK.

Williamstown, Mass.

### Germany's Finger in the Platinum Pie

*To the Editor of Chemical & Metallurgical Engineering*

SIR:—I desire to protest most energetically against the reference to me contained in your recent editorial, entitled "Germany's Finger in the Platinum Pie," and I submit that such an article should not have been published, without giving me an opportunity to enlighten you in regard to the matters referred to therein, as to which you confess ignorance.

I did not come to this country as the emissary or agent of any one. I have been connected with Baker & Co., Inc., and the American Platinum Works, since their organization and no German capital was ever employed directly or indirectly in their expansion, unless a former one-fifth interest in their capital stock can be so regarded.

As to the Draper incident, which you feature so prominently in your article, I would state that my advice was not asked in the matter, nor offered, nor had I at that time even met Mr. Summers.

I have lived in this country for over twenty-five years, have been an American citizen for many years and yield to no one in my admiration of our laws and institutions. I have never served in any official capacity to our Government, and, like any other loyal American citizen, have answered in the most conscientious

manner only such questions as were put before me, thus endeavoring to give to our Government the benefit of any special knowledge I might possess in regard to platinum.

I have nothing to fear or conceal. My record is well known to our Government, and I demand only justice from my fellow-citizens.

CHARLES ENGELHARD

New York.

*To the Editor of Chemical & Metallurgical Engineering*

SIR:—Your editorial entitled "Germany's Finger in the Platinum Pie," which appeared in your issue of August 15, in so far as it suggests that the undersigned company has been or is subject to German influence, is unjust, misleading and directly contrary to facts. None of our stock is now owned, or since nearly a year previous to our entry into the war, has been owned by any German or ally of Germany, nor does any enemy or ally of an enemy influence or control our management directly or indirectly in the slightest degree.

At no time in our history has any German interest owned more than one-fifth of our stock, nor did such stock exercise any special influence in our management, nor has German capital or credit contributed in any other respect to our expansion or growth. On the other hand, we include among our largest stockholders Mr. Charles W. Baker and the Estate of Mr. Cyrus O. Baker, of Newark, the well-known English firm of Johnson, Matthey & Co., Ltd., and the French firm now Quennessen, de Belmont, Legendre & Co. The Bakers are of old American stock; Johnson, Matthey & Co., Ltd., are the direct representatives of the British Government as regards platinum, and needless to say would not be associated with any pro-German interests in this country.

BAKER & COMPANY, INC.

Newark, N. J.

### Dye-Stuff Symposium at Cleveland

*To the Editor of Chemical & Metallurgical Engineering*

SIR:—At the American Chemical Society meeting in Cleveland there will be a dye-stuff symposium on Tuesday at 2 o'clock, September 10, which will also continue over into Wednesday morning.

All phases of the chemistry of dye-stuffs will be under discussion and a number of papers by experts in this line will be presented. The meeting will also be thrown open to general discussion.

It is expected that out of this initial dye-stuff symposium there will arise regular meetings of those interested in the chemistry of dye-stuffs at the conventions of the American Chemical Society for the purpose of discussing and encouraging the development of the chemistry of these materials.

As this phase of the dye-stuff industry is so essential to its ultimate development, we are asking hearty cooperation of all interested.

R. NORRIS SHREVE,

Chairman, Dye-Stuff Symposium

Calco Chemical Company,  
Bound Brook, N. J.



## Western Chemical and Metallurgical Field

### American Zinc Institute.

OVER 150 men interested in the mining and smelting of zinc met in St. Louis July 29 to consider ways and means of bettering the economic condition of the metal through their coöperative action. The result of this conference, said to be the first in the history of zinc mining, was the appointment of a committee to effect the permanent organization of the American Zinc Institute. This committee on organization consists of the following men, well known to the industry: Victor Rakowsky, Joplin, Mo.; J. L. Bruce, Butte and Superior Mining Co., Butte, Mont.; E. H. Wolff, Illinois Zinc Co., Peru, Ill.; A. B. McMillan, Edgar Zinc Co., St. Louis, Mo.; Chas. T. Orr, Athletic Mining and Spelter Co., Webb City, Mo.; A. P. Cobb, New Jersey Zinc Co., New York City; and W. F. Rossman, American Zinc, Lead and Smelting Co., St. Louis, Mo.

The recent history of the zinc market is well known. It was the first common metal to be demanded in unusual quantities by our allies, but over a year ago the ready expansion of American mines and mills changed an excess demand into an overproduction, and the price rapidly fell. The low point of 6½ was higher than the normal pre-war average of 5½, but increasing commodity process caused sharp curtailment by producers.

The problems awaiting solution by the American Zinc Institute may be realized when one considers the difficulties which the American industry are now weathering, despite the embargo on ore shipments from abroad and the exclusion of the Mexican ore by refusing it railway equipment for transportation from ports of entry. With the field absolutely pre-empted there is today but 60 per cent of the present live distilling capacity operating. Prospective American exporters cannot realize too early that when transportation is normalized the severest competition will have to be met in foreign markets. At present it may be easier to exact a better price for metal than to use real brains to lower its cost; but after the war the decisions of the War Industries Board will have small interest to the Spaniard who asks for specifications. If it is to succeed, the energies of the Institute may well be diverted from the monopolistic fixation of prices and expended on the larger labors of research for increased mining and metallurgical efficiency and for new uses for the metal, and to acquire and disseminate among their membership and the general public statistical and other information as to production, costs, and uses.

Other metallurgical and chemical industries may well profit by the experience in zinc. The soaring price of a war bride has killed that one market absolutely necessary for continued operation, the steady, small-lot, home consumption. If copper, steel, lumber and others follow the example of zinc, the most drastic price cutting will be necessary at the war's end in order to re-educate the consumers to the old-fashioned uses of common commodities.

### Prices Fixed for Sheet and Plate Zinc

The President has approved an agreement made between the producers of sheet and plate zinc and the Price Fixing Committee of the War Industries Board (after investigations by this committee in conjunction with the Federal Trade Commission as to the cost of production) that the maximum base price of fourteen cents per pound f.o.b. plant for plate zinc, and fifteen cents per pound f.o.b. plant for sheet zinc, shall be continued on deliveries from Sept. 1, 1918, to Jan. 1, 1919, subject to the usual trade discounts and extras or differentials that were in effect Feb. 13, 1918. These discounts and extras shall be effective on all contracts executed between Feb. 13, 1918, to Jan. 1, 1919. Sheet zinc shall be considered as including all gages of one-eighth inch thickness and less and plate zinc as including all gages thicker.

The conditions are, as formerly: First, that the producers of plate and sheet zinc will not reduce the wages now being paid; second, they will sell to the Allies, to the public, and to the Government at the same price; third, that they will take the necessary measures, under the direction of the War Industries Board, in the distribution of plate and sheet zinc to prevent it from falling into the hands of speculators who might increase the price to the public; and fourth, that they pledge themselves to exert every effort necessary to keep up the production of plate and sheet zinc so as to insure an adequate supply as long as the war lasts.

### Work Suspended on Muscle Shoals Hydro-electric Power Project

The War Department after consultation with the War Industries Board has ordered the suspension of work on the dam and other construction for the hydro-electric power project at Muscle Shoals, Alabama. In making this statement to the Washington correspondent of *CHEMICAL & METALLURGICAL ENGINEERING*, Benedict Crowell, assistant secretary of war, pointed out that no stoppage of work on the building of the nitrate plant at Muscle Shoals is in contemplation nor is there any contemplation of stoppage of work at the Cincinnati, Toledo and other plants. In fact there are estimates obtainable in Washington that the nitrate plant at Muscle Shoals will be placed in production this year.

While the work on the hydro-electric development at Muscle Shoals is announced as being suspended temporarily, it is nevertheless the belief in Washington that this work has been suspended for the period of the war. Three years would be required to complete this work and it is plainly stated at the War Department that in view of this fact the work is of a non-essential character. In other words, the belief is entertained in Washington that the war will be over before this particular power plant could be placed in production.

The decision to abandon the Muscle Shoals hydro-electric plant came as the result of a request to the War Industries Board that this project be placed on the list for priority as an essential undertaking but the Board held that the labor and material being used there and in contemplation are urgently required to meet more immediate war demands. In this view the War Department has concurred.

## Emergency Bill in Congress for Federal Control of Power Resources

**T.** W. SIMS, chairman of the House committee on interstate and foreign commerce, has introduced in the House of Representatives a bill "to provide further for the national security and defense and for the more effective prosecution of the war by furnishing means for the better utilization of the existing sources of electrical and mechanical power and for the development of new sources of such power." The bill provides the sum of \$150,000 for administrative expenses and provides the sum of \$200,000,000 for the purchase and building of power plants.

The proposed legislation is to be known as the emergency power act. It is not to be confused with the water-power bill now pending in the House of Representatives and will not be considered in connection with that bill, which is all ready on the floor of the House, while the emergency power act has but just been referred to the committee. Hearings on the emergency power act were begun before the House interstate and foreign commerce committee on Aug. 23. The War Industries Board, the Treasury Department and the Shipping Board served notice on the committee that it was desired that representatives of these governmental agencies should testify at the hearings.

In making the bill public, Representative Sims issued a statement in part as follows:

We are facing a power shortage which is and for some time past has been acute and is hampering our progress on war production. So this measure authorizes the President to erect power stations near the coal mines and at other points where he may deem them necessary, or to extend financial aid to persons or corporations about to do so, and therefore desiring to secure results of tremendous, immediate and inestimable value to America. It is considered necessary by representatives of the administration, by representatives of the great power companies and by economists who attacked the problem from various viewpoints, and is endorsed by all of them.

This bill must not be misunderstood as in any wise taking the place of the water-power bill now before the House. That is in its nature a peace-time measure, and the provisions of the two do not conflict. The plans are to confer upon the President all necessary power to deal with the urgent power situation properly and effectively and to place at his disposal sufficient funds with which to assure adequate operation. The bill contains:

1. Increased production of power available for war industries and shipyards.
2. Economy in the use of fuel.
3. Reduction in the railroad freight load, especially in the fuel load.
4. Increased production of metallurgical coke, toluol, ammoniacal liquor, all recovered from coal.

The bill grants sweeping authority to the President and includes penalties of imprisonment or fine or both for any who knowingly neglect or refuse to comply with any order or requisition made by the President or any officer or agency designated or created under the act.

**New Electric Smelting Furnaces in Sweden.**—Having doubled its capital and made it \$724,000 the Aktiebolaget Porjus Smältverks proposes to build two electric smelting furnaces this summer. The company has already three furnaces in operation. The company's power is secured from the Porjus waterfall. It expects to manufacture 20,000 metric tons of pig iron each year. —*Consular Reports.*

## Electric Furnace Manufacturers Confer on War Problems

**E**LECTRIC furnace manufacturers who are organized under the name of the Electric Furnace Industries War Service Committee, met in New York City on Aug. 20 to consider what steps should be taken for their welfare, in view of the possibility of action by the War Industries Committee curtailing construction of new plants for steel castings. As outlined in *CHEMICAL & METALLURGICAL ENGINEERING*, Aug. 15, page 171, the electric furnace industry is confronted with the fact that the War Industries Board may find it necessary to grant no new permits for electric steel casting plants, due to the fact that there is already ample casting capacity.

The Executive Committee of the organization, comprising G. H. Clamer, F. N. Castle, C. P. Fletcher and F. J. Ryan, discussed the entire situation with the following members of the association: C. H. Booth, F. W. Brooke, H. A. DeFries, C. H. VomBaur, T. F. Baily and D. D. Miller. Although considerable time was devoted to a discussion of the electrode situation, the association properly concluded that this phase of the matter was not of immediate concern to electric furnace manufacturers, but that the controlling factor was whether or not there is already an ample capacity in the country for steel castings. Being in agreement on this point the meeting passed a resolution to the effect that the Executive Committee of the organization should confer with the Steel Division of the War Industries Board to ascertain whether or not there is now a shortage of capacity for steel castings and whether new capacity is essential. The Executive Committee is to report its findings to the members of the organization and further action is to be taken after this report is received. All of the furnace manufacturers are in agreement to abandon further efforts to establish new electric steel casting plants if the War Industries Board satisfies them that there is now ample supply for all needs.

## Ordnance Board on Metallurgical Matters

In order to assure the more complete coordination of the various Ordnance Departmental activities along metallurgical lines, it has been decided to establish a Board on Metallurgical Matters. The appointment of this board will also assure the complete coordination of similar activities of the different divisions of the War Department and the War Industries Board.

The personnel of the board is as follows: Dr. G. W. Sargent, Engineering Division, chairman; Lt. Col. W. P. Barba, Production Division; Major A. E. White, Inspection Division, representing the Ordnance Department; Lt. Col. F. B. Richards, of the office of the Assistant Secretary of War; Mr. L. L. Summers, representing the War Industries Board, and Mr. William H. Smith, representing the manufacturers.

The board will act not only for the various sections of the Ordnance Department but also in connection with the manufacturers working for and with the department in the production of war material, and will gather the most recent and complete information on all metallurgical products.

## Disposition of Chemists in the Army

**A**S A RESULT of a letter from the Adjutant General of the Army, dated May 28, 1918, 1749 chemists in the army have been reported on. Of these the report of actions to August 1, 1918, shows that 281 were ordered to remain with their military organization because they were already performing chemical duties; 34 were requested to remain with their military organization because they were more useful in the military work which they were doing; 12 were furloughed back to industry; 165 were not chemists in the true sense of the word and were, therefore, ordered back to the line; and 1294 are now placed in actual chemical work. There were being held for further investigation of their qualifications on August 1, 1918, 432 men. The remaining 23 men were unavailable for transfer, because they had already received their overseas orders.

The 1294 men, who would otherwise be serving in a purely military capacity and whose chemical training is now being utilized in chemical work, have, therefore, been saved from waste. Each case has been considered individually, the man's qualifications and experience have been studied with care, the needs of the Government plants and bureaus have been considered with equal care, and each man has been assigned to the position for which his training and qualifications seem to fit him best. Undoubtedly, there have been some cases in which square pegs have been fitted into round holes, but, on the whole, it is felt that the adjustments have been made as well as could be expected under the circumstances. Where readjustment is necessary, subsequent action will be taken.

## Enemy Patent Licenses Issued by Federal Trade Commission

Following is a complete list of enemy patent licenses issued by the Federal Trade Commission. It is significant of the activity of the German people along chemical lines to note that over 80 per cent of the licenses granted are for patented chemical processes and products not hitherto used or produced by American chemists.

### PATENT LICENSES ISSUED

Non-exclusive. The Dermatological Research Laboratories, 1818 Lombard St., Philadelphia, Pa. Arsphenamine, Nov. 26, 1917. Neo-arsphenamine, Mar. 4, 1918.

Non-exclusive. Takamine Laboratory, Inc., 120 Broadway, New York City. Arsphenamine, Nov. 26, 1917. Neo-arsphenamine, Mar. 4, 1918.

Non-exclusive. Farbwerke-Hoechst Company, 122 Hudson St., New York City. Arsphenamine, Nov. 26, 1917. Neo-arsphenamine, Mar. 4, 1918. (License cancelled and license issued to H. A. Metz Laboratories, Inc., in its place.)

Non-exclusive. H. A. Metz Laboratories, Inc., 122 Hudson St., New York City. Arsphenamine, July 19, 1918. Neo-arsphenamine, July 19, 1918.

Non-exclusive. Diarsenol Company, Inc., 475 Ellicott Square, Buffalo, N. Y. (Factories in Toronto, Canada.) Arsphenamine, Jan. 12, 1918. Neo-arsphenamine, Mar. 4, 1918.

Non-exclusive. Farbwerke-Hoechst Company, 122 Hudson St., New York City. Procaine, Dec. 17, 1917. (License canceled and license issued to H. A. Metz Laboratories, Inc., in its place.)

Non-exclusive. H. A. Metz Laboratories, Inc., 122 Hudson St., New York City. Procaine, July 19, 1918.

Non-exclusive. Rector Chemical Company, Inc., 2 Rector St., New York City. Procaine, Dec. 17, 1917.

Non-exclusive. The Abbott Laboratories, 4739-57 Ravenswood Ave., Chicago, Ill. Barbitol, Dec. 17, 1917.

Non-exclusive. The Abbott Laboratories, 4739-57 Ravenswood Ave., Chicago, Ill. Procaine, Jan. 10, 1918.

Non-exclusive. The Abbott Laboratories, 4739-57 Ravenswood Ave., Chicago, Ill. Phenyl Cinchoninic Acid, Mar. 23, 1918.

Exclusive. Pacific Flush Tank Company, 4241-43 Ravenswood Ave., Chicago, Ill. Sewage Treatment Apparatus, Dec. 17, 1917. (Limhoff Tank.)

Exclusive. Lembeck, von Bernuth Company, Inc., 171 Madison Ave., New York City. Rueping Process of Treating Timber, Jan. 17, 1918.

Exclusive. Hoevel Manufacturing Corporation, 50 Church St., New York City. Sand Blast Machine, Feb. 18, 1918.

Non-exclusive. Calco Chemical Company, Inc., Bound Brook, N. J. Procaine, Feb. 18, 1918.

Non-exclusive. French Battery & Carbon Company, Madison, Wis. Depolarizer for Galvanic Cells, Feb. 18, 1918.

Non-exclusive. Antoine Chris Company, 18 Platt St., New York City. Barbitol, Mar. 11, 1918.

Non-exclusive. New Process Metals Co., Inc., 50 E. 41st St., New York City. Pyrophoric Alloy, Pyrophoric Mass, Mar. 30, 1918.

Non-exclusive. Pfanstiehl Company, Inc., North Chicago, Ill. Pyrophoric Alloy, Mar. 30, 1918.

Non-exclusive. E. I. duPont de Nemours & Co., Wilmington, Del. Anthracene, Indigo, Sulphur and Azo Dyes, Jan. 21, 1918.

Non-exclusive. Albert B. Moses, 909 Eighth Ave., Seattle, Wash. Artificial Milk, Apr. 8, 1918.

Exclusive. F. L. Smith & Co., 50 Church St., New York City. Ball-Mill, Apr. 8, 1918.

Non-exclusive. E. C. Klipstein & Sons Company, 644 Greenwich St., New York City. Hydrosulfites (Dyes), Apr. 8, 1918.

Non-exclusive. The Hagan Corporation, People's Bank Building, Fourth Ave. and Wood St., Pittsburgh, Pa. Suction Device for Dust-laden Air, May 3, 1918.

Exclusive. American Parlograph Corporation, 123 Liberty St., New York City. Talking Machine, May 7, 1918.

Non-exclusive. National Aniline & Chemical Co., Inc., 21 Burling Slip, New York City. Anthracene, Indigo, Sulphur and Azo Dyes, June 28, 1918.

Non-exclusive. Robert Reiner Importing Company, Gregory Ave. and Hackensack Plank Road, Weehawken, N. J. Embroidering Machines, July 10, 1918.

Non-exclusive. The Stearns-Roger Manufacturing Company, 1720 California St., Denver, Colo. Cellular Drying Apparatus, July 16, 1918.

Non-exclusive. Merrimac Chemical Company, 148 State St., Boston, Mass. Hydrosulfites (Dyes), July 16, 1918.

Non-exclusive. General Ceramics Company, 50 Church St., New York City. Absorption and Reaction Tower for Acids, July 19, 1918.

### TRADE-MARKS

Exclusive. Lehn & Fink, 120 William St., New York City. Pebecco (Tooth-Paste), Dec. 17, 1917.

Exclusive. The Anchor Packing Company, Lafayette Building, Philadelphia. Tauril, Feb. 49, 1918.

Non-exclusive. The Abbott Laboratories, 4739-57 Ravenswood Ave., Chicago, Ill. Veronal, Dec. 17, 1917.

## Sulphur Syndicate in Sicily

The report that accompanies the draft of the bill for granting an extension of 12 years to the syndicate interested in the sulphur production of Sicily intimates that such extension has been asked for in order to protect the principal industry of Sicily, which is confronted with greater foreign competition at a time when not only larger quantities of the product are needed for explosives but labor for working the mines is scarce. It is believed, that the intensifying of the Japanese production, the discovery of deposits in northern Africa, and the very considerable American output constitute a serious menace to the native industry. In view of the situation, therefore, it is believed that by extending for 12 years the rights of the syndicate, whose special work it is to combine and regulate the efforts of the individual producers, efficient means will be adopted for meeting the competition of the future.—*Canadian Bulletin of Trade and Commerce.*



War Department Orders New Census of Chemists

THE following open letter has been addressed to the chemists of the United States by Maj. Gen. William L. Sibert, Director of Chemical Warfare Service. The communication pertains to a new census of chemists in the United States which the War Department has found necessary in view<sup>a</sup> of the changes that have occurred since the census taken at the beginning of the war by Dr. Charles L. Parsons, Chief Chemist of the United States Bureau of Mines and Secretary of the American Chemical Society. All chemists in the United States will receive a questionnaire, which we reproduce herewith, and they should be at special pains to make a prompt return so that the War Department can be in possession of the knowledge which it now finds necessary. By returning the blank properly executed, no one binds himself in any way to any service of the Government, but he will put the War Department in possession of the necessary knowledge to enable it to turn to the chemists of the country for aid or advice.

WAR DEPARTMENT  
CHEMICAL WARFARE SERVICE  
WASHINGTON, D. C.

September 1, 1918.

TO THE CHEMISTS OF THE UNITED STATES:

This is a chemical war; therefore the War Department must have immediately available all possible information regarding chemical materials and chemical man power. Of these two essential elements chemical man power has so far received less attention. The census of American chemists made by the American Chemical Society in 1917 has been of great assistance to the War Department. Without it the present state of progress of the United States in chemical warfare would have been impossible of attainment.

However, during the same period conditions have undergone rapid and radical changes. The old census, excellent as it was, is no longer completely adequate. With the organization of the Chemical Warfare Service as an independent branch of the War Department, unifying all the elements of chemical warfare, it is obvious that the War Department must have its own set of records on a matter so vital to its own success. Moreover, these records must contain information which a short time ago was apparently of little importance. The new census must be made primarily from the viewpoint of the military status of chemists.

The importance of a prompt return of the census blank, properly filled out, by every chemist of the country cannot be overstated. American chemists are presented at this moment with one of the greatest opportunities to serve their country by the simple process of answering this questionnaire with all possible speed.

(Seal) (sgd.) WILLIAM L. SIBERT,  
Major General, U. S. A.,  
Director of Chemical Warfare Service.

QUESTIONNAIRE

Date.....  
Name .....  
          (Last)          (First)          (Middle)  
Present address .....  
Permanent address .....

I. GENERAL

1. Born (a) Date ..... (b) Place.....  
2. Age ..... 3. Place of birth (a) of father.....  
          (b) of mother ..... 4. Are you an American citizen?..... 5. If naturalized, give date ..... 6. Are you married?.....  
7. Is your wife living? ..... 8. How many peo-

ple are dependent upon you (a) wholly?.....  
(b) partially? .....

II. TRAINING

9. Give the names of the schools, colleges, universities, graduate schools, or technical schools, which you have attended, with dates of attendance, courses pursued, and degrees granted.  
.....  
Institutions      Dates      Courses pursued      Degree  
.....  
10. State any other training you have had.....  
11. State fully the courses of study in which you have specialized .....  
12. What foreign languages do you (a) speak.....  
          (b) read? ..... (c) write .....  
13. Of what technical societies are you a member?  
.....

III. PRACTICAL EXPERIENCE

14. In what foreign countries have you had experience and how much? .....  
15. How many years of continuous experience have you had? .....  
          (a) Industrial ..... (b) Teaching .....  
          (c) Other .....  
16. What experience have you had along executive and administrative lines? .....  
17. State in detail your duties in your various positions.  
.....

| From—To | Employer | Title | Nature of work | Salary (Statement optional and confidential) |
|---------|----------|-------|----------------|----------------------------------------------|
| .....   | .....    | ..... | .....          | .....                                        |

18. Publications.

| Title | Publisher | Date  |
|-------|-----------|-------|
| ..... | .....     | ..... |

19. State specifically the kind of work you do best .....  
20. In the present emergency how and where, in your opinion, could you be of most service to your country?  
.....

IV. SERVICE

21. Do you desire to enter the service of the United States at once (a) in a civilian capacity?.....  
          (b) in a military capacity? .....  
Note. If you answer this question in the affirmative, answer the rest of the questions in this section insofar as they apply to your case: Otherwise, skip to section V.  
22. What rank (or salary, if you desire a civilian appointment) would you accept? .....  
23. What has been your total military experience? .....  
24. Are you registered in the draft? .....  
25. What is your Order Number? .....  
26. What is your Serial Number? .....  
27. Have you received the draft questionnaire?.....  
28. How have you been classified?.....  
29. Give names and addresses of three or four responsible persons (not relatives) or send letters of recommendation herewith.  
.....

| Name  | Address |
|-------|---------|
| ..... | .....   |

V. MISCELLANEOUS

30. State anything else, which will aid us, or which you want us to know, which is not covered by the questions on this folder. (Answer this question last.)  
.....  
Please re-read this whole questionnaire and sign below.  
Signature .....

# Chemical Warfare Service, National Army

## An Account of the Inception and Development of the Chemist's Part in Military Operations—Organization of the Service—Commissioned Personnel Here and Overseas

GENERAL Order No. 62 of the War Department dated June 28, 1918, will always have special significance to the chemists of the United States because therein the Secretary of War, at the direction of the President, organized the Chemical Warfare Service of the National Army.

### DEVELOPMENTS BY THE BUREAU OF MINES

The evolution of the Chemical Warfare Service is interesting because it had its inception in a branch of the Government not concerned with warfare, namely, the Bureau of Mines of the Department of the Interior. On account of the familiarity of the Bureau with noxious gases in mines, it was able to make an early start on the important work of gas warfare at a time when the War Department was deluged with other important problems. The result is that we have heard no criticism of delay in the gas warfare work such as has been directed at other branches. An important feature of the work of the Bureau was the wonderful coöperation which it secured from the leading chemists of the country who responded willingly and promptly to the call. This enabled the Bureau to turn over to the War Department a complete, well articulated organization of more than 1,800 chemists which had accomplished great things prior to being transferred.

Early in February of 1917, when war between the United States and the Central Powers seemed inevitable, the Bureau of Mines called the attention of the War Department to the already existing technical organization in the Bureau for the study of poisonous gases in mines, gas masks etc., and offered the facilities of the Bureau to the War Department for this work. A meeting was arranged between representatives of the Bureau and the War College. At this conference the War Department enthusiastically accepted the offer of the Bureau of Mines and agreed to support the work in every way possible.

The Director of the Bureau of Mines immediately directed investigations of these war problems, and until July 1, 1917, carried the work along with funds of the Bureau. The first work was done on the development of gas masks. On July 1, 1917, the staff consisted of fifty paid investigators and the work had expanded from gas-mask research to the study of poison gases and chemical warfare appliances for offensive purposes.

### COÖPERATION OF UNIVERSITIES AND RESEARCH ORGANIZATIONS

In order to enlist the coöperation of the universities and research institutions in the United States, personal visits were made to practically all of the important ones. The response was most gratifying. Up to the present time some extremely important work has come out of these universities and institutions. On April 6, 1917, the following committee on gases used

in warfare was formed by the National Research Council for the purpose of coöperating with the Bureau of Mines in connection with this work:

Van. H. Manning, Chairman, Director, U. S. Bureau of Mines.

George E. Hale, (Ex-Officio)

National Research Council, Director, Mt. Wilson Solar Observatory.

Lt. Col. R. A. Millikan, (Ex-Officio) National Research Council

..... Science and Research Division, Signal Corps.

Carl L. Alsberg, ..... Chief, Bureau of Chemistry, U. S. Department of Agriculture.

Maj. Earl J. Atkisson, ..... Corps of Engineers, U. S. A.

Lt. Col. Marston T. Bogert, ..... Chemical Service, N. A.

Lt. Col. Bradley Dewey, ..... Gas Defense Service, Surgeon General's Office.

A. H. Marks, ..... Director, Gas Service, U. S. A.

Lieut. Joseph R. Phelps, ..... P. A. Surgeon, Bureau of Medicine and Surgery, U. S. N.

Lt. Col. Earl J. W. Ragsdale, ..... Bureau of Ordnance, U. S. A.

Lieut. T. W. Wilkinson, ..... Bureau of Ordnance, U. S. N.

This committee has worked in hearty coöperation with the Bureau of Mines.

Until August, 1917, the Bureau of Mines also supervised the construction of gas masks.

On November 7, 1917, Secretary Lane appointed the following Advisory Board to the Director of the Bureau of Mines on war problems: Dr. Wm. H. Nichols, Prof. E. C. Franklin, Dr. C. L. Parsons, Mr. Wm. Hoskins, Prof. H. P. Talbot, Dr. F. P. Venable, Dr. Ira Remsen, Prof. T. W. Richards.

Since that date the Board acted in an advisory capacity to the Director on the gas work, both as individuals and as a body. The Board first met on Monday, December 17, 1917, and visited the laboratories and consulted with the research staff. They were also given a demonstration of the work in progress and full reports were made to the Board by all section chiefs. A second meeting was held on May 15 and 16, 1918, when the work was again reviewed.

It was finally decided that the Bureau of Mines would remain as a research organization, making recommendations to the Army and Navy regarding the kinds of masks and nature of gases to be used, together with their method of manufacture, and that the construction of the mask proper should be transferred to the Surgeon General's Office of the Army. The organization working for the Bureau of Mines was turned over to this department of the Army and formed the nucleus of the present huge organization working on the construction of gas masks and other appliances for gas defense.

On September 15, 1917, many of the experimenters working for the Bureau of Mines on war gas problems moved into the present headquarters of the organization at the American University, on the outskirts of Washington. The University authorities turned over the use of two large buildings at this place, rent free, but with the

proviso that some of the alterations and additions, necessary for the proper conduct of the work, would be permanent and become the property of the University after the war was over. The lease of the buildings and grounds of the University extends to a period two years from July 1, 1917, or during the war if it should extend beyond the two-year period.

#### CHEMICAL SERVICE SECTION ORGANIZED IN NATIONAL ARMY

In December, 1917, a chemical corps was established in the National Army and a part of the unit sent to France. This unit is composed largely of men trained in the Bureau of Mines' organization. In December, also, a staff of chemical engineers, working for the research organization of the Bureau of Mines, developing processes for manufacturing gases, was transferred to the Bureau of Ordnance of the War Department and formed the nucleus of the present organization, building huge plants for the manufacture of poison gases. Another organization, which had its inception under the Bureau of Mines, and has for its head a man who worked for the Bureau and received his training on noxious gas methods, is the proving-ground unit of the War Department, established at Gunpowder Neck, for actually trying out gases on an artillery scale after they have been studied by the research organization.

The personnel of the research organization also included a group working on chemical warfare devices. These substances include aeroplane gas bombs, signal lights, smoke screens to screen merchant ships from enemy submarines, gas shells, incendiary shells, gas bombs, trench projectors for firing gas bombs, flaming guns etc., and important recommendations have gone from the research organization covering such materials which have been adopted by departments of the Army and Navy interested and put into production.

In recapitulating the work of the Bureau of Mines it may be said that, by inaugurating the gas warfare program with the hearty support of the Army and Navy departments, the National Research Council, state educational, and private institutions, we are undoubtedly months ahead of where we otherwise would have been; that our soldiers have gas masks, and will have gases with which to combat the Germans; further, that the developments in gas mask manufacture by the Surgeon General's Office of the Army, in gas manufacture and gas proving-ground tests by the Bureau of Ordnance, and in the chemical warfare program of the Navy, including the use of smoke screens, shells, toxic gases etc., are the results from this experimental work.

The scientific achievements of the Bureau of Mines have been many, but the results cannot be given at this time for reasons that are obvious. It is sufficient to say that due to the energy of the research organization of the Bureau of Mines, the large scale production of toxic gases is far ahead of the supply of shells.

The Advisory Chemical Board said of the work being done by the Bureau of Mines: "The efficiency, success, fine spirit, and enthusiasm under the leadership of the Bureau of Mines is a matter upon which we wish to congratulate the Bureau, as well as upon the splendid group of unselfish, self-sacrificing men who carried on this arduous and dangerous work."

At that time before the transfer of the work the

Chemical Board added: "The organization is complex and delicate but well articulated and working with an efficiency and enthusiasm which has impressed us greatly."

#### WORK COÖRDINATED AND CONSOLIDATED BY THE PRESIDENT

As the war progressed, it became apparent that, in the interest of economy and more efficient concentration of the work, certain bureaus and agencies should be co-ordinated or consolidated. Accordingly, the experiment station at American University, which had been under the control of the Bureau of Mines, was transferred to the War Department, in which connection the following correspondence passed between Secretary of War Baker, the President and Director Manning of the Bureau.

#### WAR DEPARTMENT WASHINGTON

June 25, 1918.

My dear Mr. President:

In connection with the proposed transfer of the chemical section at American University from the Bureau of Mines to the newly constituted and consolidated Gas Service of the War Department, which you are considering, I am specially concerned to have you know how much the War Department appreciates the splendid services which have been rendered to the country and to the Army by the Department of the Interior, and especially by the Bureau of Mines under the direction of Dr. Manning. In the early days of preparation and organization, Dr. Manning's contact with scientific men throughout the country was indispensably valuable. He was able to summon from the universities and the technical laboratories of the country men of the highest quality and to inspire them with enthusiastic zeal in attacking new and difficult problems which had to be solved with the utmost speed. I do not see how the work could have been better done than he did it, and the present suggestion that the section now pass under the direction and control of the War Department grows out of the fact that the whole subject of gas warfare has assumed a fresh pressure and intensity, and the director of it must have the widest control so as to be able to use the resources at his command in the most effective way possible. The proposal does not involve the disruption of the fine group of scientific men Dr. Manning has brought together, but merely their transfer to General Sibert's direction.

Respectfully yours,  
The President. (Signed) Newton D. Baker.

THE WHITE HOUSE  
WASHINGTON

26 June, 1918

My dear Dr. Manning:

I have had before me for some days the question presented by the Secretary of War involving the transfer of the chemical section established by you at the American University from the Bureau of Mines to the newly organized Division of Gas Warfare in which the War Department is now concentrating all the various facilities for offensive and defensive gas operations. I am satisfied that a more efficient organization can be effected by having these various activities under one direction and control, and my hesitation about acting in the matter has grown only out of a reluctance to take away from the Bureau of Mines a piece of work which thus far it has so effectively performed. The Secretary of War has assured me of his own recognition of the splendid work you have been able to do, and I am taking the liberty of enclosing a letter which I have received from him, in order that you may see how fully the War Department recognizes the value of the services.

I am to-day signing the order directing the transfer. I want, however, to express to you my own appreciation of the fine and helpful piece of work which you have done, and to say that this sort of team work by the bureaus outside of the direct war-making agency



is one of the cheering and gratifying evidences of the way our official forces are inspired by the presence of a great national task.

Cordially yours,  
(Signed) Woodrow Wilson.

Dr. Van. H. Manning,  
Chief, Bureau of Mines,  
Department of the Interior.

#### FORMAL ORGANIZATION OF THE NEW SERVICE

As stated in the opening paragraph, the War Department finally ordered the organization of the Chemical Warfare Service, National Army, to remain in full force and effect during the continuation of the present war and for six months after the termination thereof.

The rank, pay, and allowances of the enlisted men of the Chemical Warfare Service, National Army, are the same as now authorized for the corresponding grades in the Corps of Engineers.

#### HEAD TO BE DIRECTOR

The head of the Chemical Warfare Service, National Army, is known as the Director of the Chemical Warfare Service, and, under the direction of the Secretary of War he is charged with the duty of operating and maintaining or supervising the operation and maintenance of all plants engaged in the investigation, manufacture, or production of toxic gases, gas-defense appliances, the filling of gas shells, and proving grounds utilized in connection therewith and the necessary research connected with gas warfare. He also exercises full, complete, and exclusive jurisdiction and control over the manufacture and production of toxic gases, gas-defense appliances, including gas-shell filling plants and proving grounds utilized in connection therewith, and all investigation and research work in connection with gas warfare.

#### FUNCTIONS OF SUBDIVISIONS OF CHEMICAL WARFARE SERVICE

The functions of the various divisions and branches are as follows:

*Overseas Division.*—This division includes personnel assigned to all divisions and corps and army headquarters in addition to those required for the supply of material in the field in France.

*Research Division.*—Charged with research into all matters pertaining to gas warfare.

*Development Division.*—For the development of material received from the Research Division to the point where it may be turned over for proving.

*Proving Division.*—Charged with the duty of proving the efficiency of material under field condition.

*Gas Defense Production Division.*—The production of material such as gas masks for use in the defensive.

*Gas Offense Production Division.*—The production of gas, containers and other material for use in offensive gas warfare.

#### FUNCTIONS OF SECTIONS IN ADMINISTRATION BUREAU

*Records.*—The recording and filing of all documents and handling mail and correspondence.

*Personnel.*—The procurement, assignment, transfer and promotion of commissioned and enlisted personnel and the listing and employment of civilians.

*Finance.*—Preparation of estimates, allotments, accounts, contracts and purchases. Handle all fiscal affairs.

*Auditing.*—The audit of all fiscal accounts.

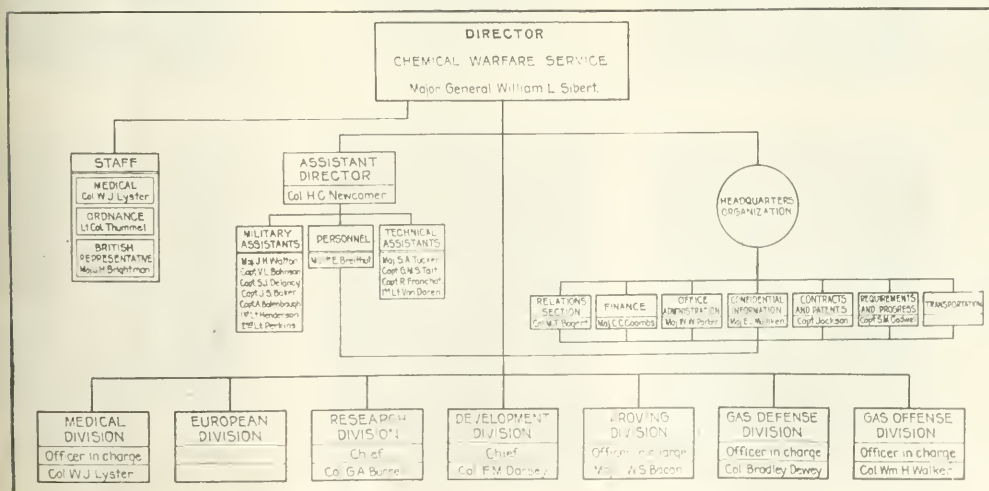
*Transportation.*—General supervision over transportation of personnel and material.

*Property.*—To be custodian of property returns required and to have charge of all property and means of transportation connected with headquarters.

*Inspection.*—To make such general and special inspections as may be required and to suggest methods for improvement in coordination between the various divisions and branches of the Chemical Warfare Service.

*New Projects.*—For the investigation of and recommendations concerning new projects.

*Training.*—Training of personnel.



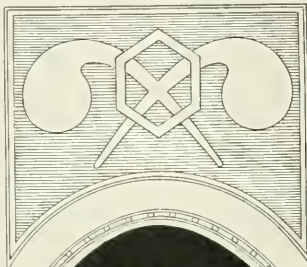
ORGANIZATION CHART, CHEMICAL WARFARE SERVICE, N. A.

# Chemical Warfare Ser

## Heads of Divisi



*Colonel Raymond F. Bacon,*  
OVERSEAS DIVISION



MAJOR GENERAL WILLIAM L. SIBERT,  
U.S.A., DIRECTOR



*Colonel Amos A. Fries,*  
OVERSEAS DIVISION



*Colonel George A. Burrell*  
RESEARCH DIVISION



*Mr. Frank M. Dorsey,*  
DEVELOPMENT DIVISION



*Major William S. Bacon,*  
PROVING DIVISION



*Colonel Bradley Dewey,*  
GAS DEFENSE DIVISION



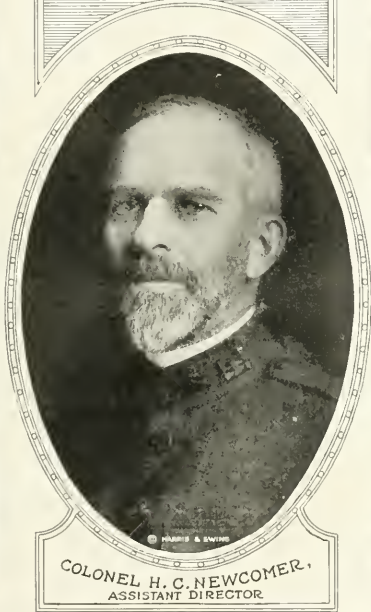
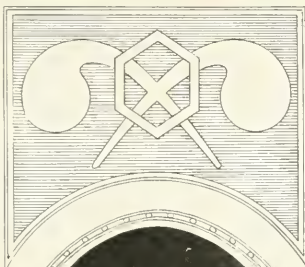
*Colonel William H. Walker,*  
GAS OFFENSE DIVISION

# vice, National Army

## ons and Sections



*Captain William K. Jackson,*  
CONTRACTS AND PATENTS SECTION



COLONEL H. C. NEWCOMER,  
ASSISTANT DIRECTOR



*Captain Sidney M. Cadwell,*  
REQUIREMENTS AND PROGRESS SECTION



*Major Victor Lehner,*  
ASSISTANT, RELATIONS SECTION



*Major S. P. Mulliken,*  
CONFIDENTIAL INFORMATION SECTION



*Colonel Marston T. Bogert*  
RELATIONS SECTION



*Major F. E. Breithut,*  
PERSONNEL SECTION



*Major Allen Rogers,*  
ASSISTANT, RELATIONS SECTION



*Information.*—To secure all information having a bearing on the Chemical Warfare Service.

#### OFFICERS AT THE HEADS OF DIVISIONS AND SECTIONS OF THE CHEMICAL WARFARE SERVICE, N. A.

Director, Major General William L. Sibert.  
 Assistant Director, Colonel H. C. Newcomer.\*  
 Overseas Division, Colonel Raymond F. Bacon and Colonel Amos A. Fries.\*  
 Research Division, Colonel George A. Burrell.  
 Development Division, Mr. Frank M. Dorsey.  
 Proving Division, Major William S. Bacon.  
 Production Division, Gas Defense, Colonel Bradley Dewey.  
 Production Division, Gas Offense, Colonel William H. Walker.

#### OFFICE ORGANIZATION AND ADMINISTRATION

##### (1) Director, Chemical Warfare Service:

Maj. Gen. Wm. L. Sibert, U. S. A.

##### Staff:

##### Medical Officer:

Col. W. J. L. Lyster, S. C.

##### Assistant:

Captain H. C. Bradley.

##### Ordnance Officer:

Lt. Col. C. B. Thummel, O. D.

##### Assistant:

Maj. C. S. Stevenson, C. W. S.

##### Representative of British Military Mission:

Maj. J. H. Brightman.

##### (2) Assistant Director, Chemical Warfare Service:

Colonel H. C. Newcomer, C. E.

To act for the Director in his absence, in charge of all military matters and new projects. Chairman, Board of Review.

##### Military Assistants:

Maj. J. H. Walton, C. W. S.

Capt. V. L. Bohannon, C. W. S.

Capt. S. J. Delancy, C. W. S.

Capt. R. A. Baker, C. W. S.

Capt. A. Bolenbaugh, C. W. S.

First Lt. R. C. Henderson, C. W. S.

Sec. Lt. F. C. Perkins.

##### Technical Assistants:

Maj. S. A. Tucker, C. W. S.

Capt. G. W. S. Tait, C. W. S.

First Lt. L. Van Doren, C. W. S.

Mr. R. Franchot.

##### (3) Office Administration.

Major W. W. Parker, C. W. S.

In charge of files and clerical personnel, receipt and distribution of mails, collection and transmission of papers between various sections of the office, office disbursements.

##### Assistants:

First Lt. F. W. Dasher, C. W. S.

Sec. Lt. W. F. Kunkle, C. W. S.

Sec. Lt. B. W. Tipton, C. W. S.

Sec. Lt. W. D. Towler, C. W. S.

##### (4) Relations Section.

Col. M. T. Bogert, C. W. S.

In charge of relations with Universities, with industries, with the office of the Director of Purchases, Storage and Traffic, and with the War Industries Board, including its committees.

##### Assistants:

Maj. Victor Lenher, C. W. S.

Maj. W. J. Noonan, C. W. S.

Maj. Allen Rogers, C. W. S.

Maj. Samuel Avery, C. W. S.

Capt. C. V. Sheehan, C. W. S.

Capt. W. H. Hickin, C. W. S.

First Lt. H. F. Scharer, C. W. S.

Geo. S. Case.

##### (5) Personnel Section.

Major F. E. Breithut, C. W. S.

In charge of all matters pertaining to procurement and assignments of commissioned and enlisted personnel of the Chemical Warfare Service.

##### Assistants:

First Lt. G. W. Phillips, C. W. S.

First Lt. H. B. Bramlet, C. W. S.

Sec. Lt. A. E. Case, C. W. S.

##### (6) Contracts and Patents Section.

Captain W. K. Jackson, C. W. S.

In charge of Section, Member of Board of Review.

##### Assistant:

Capt. R. B. Meckley, C. W. S.

##### (7) Finance Section.

Major C. C. Coombs.

In charge of estimates, appropriations and allotments, of administrative audit of all disbursing accounts and of property. Member of Board of Review, C. W. S.

##### Assistant:

Capt. Ben Jenkins, C. W. S.

##### (8) Requirements and Progress Section.

Capt. S. M. Cadwell, C. W. S.

In charge of Section.

##### Assistant:

Sec. Lt. J. A. Schon, C. W. S.

##### (9) Confidential Information Section.

Major S. P. Mulliken, C. W. S.

In charge of Section.

##### Assistant:

Sec. Lt. H. E. Moore, C. W. S.

##### (10) Transportation Section.

Officer in charge not yet selected.

##### Assistant:

Capt. H. R. Sharkey, C. W. S.

#### COMMISSIONED PERSONNEL, CHEMICAL WARFARE SERVICE, N. A.

##### COLONELS

Raymond F. Bacon  
 Marston T. Bogert  
 George A. Burrell  
 Bradley Dewey  
 Wm. H. Walker

\*Have been nominated by the President for promotion to the rank of Brigadier General.

## LIEUTENANT COLONELS

Arthur L. Besse Wm. McPherson  
Edwin M. Chance Jas. F. Norris  
Chas. F. Vaughn

## MAJORS

Chas. Almy, Jr. Samuel P. Mulliken  
Samuel A. Avery Adrian Nagelvoort  
Wm. S. Bacon Wm. J. Noonan  
Theo. H. Barth Walter W. Parker  
Fred'k E. Breithut Philip L. Reed  
T. Mitchell Chance Chas. E. Richardson  
Edward B. Clark Allen Rogers  
J. B. Conant Reed P. Rose  
Dara J. Demerest Henry P. Schuit  
Fred'k A. Dewey Wm. O. Sibert  
Edgar M. Dunn Theo. W. Sill  
Wm. L. Evans Oscar E. Stevens  
Francis C. Frary C. S. Stevenson  
Edw. E. Free Orland R. Sweeney  
Wm. G. Gallowhur Sterling M. Temple  
Hugo H. Hanson Samuel A. Tucker  
Percy D. Houghton Edgar D. Van Zeuren  
Arthur M. Heritage Frank J. Wagner  
Cleon R. Johnson J. H. Walton  
W. Catesby Jones Irving W. Wilson  
Victor Lenher Robert E. Wilson  
William G. Lockwood John C. Woodruff  
Frank W. Mack Chas. R. Wraith  
Stephen R. Morey Arcalons W. Wyckoff  
Frederick G. Zinsser

## CAPTAINS

John A. Armory A. T. Larson  
James Armstrong Lewis L. Latimer  
Kirby Atterbury James Lawrence  
J. Stanley Babbitt Stanley H. Lawton  
R. O. Bailey Arthur C. Levering  
Ross A. Baker John S. Little  
T. W. Balfe Harris Livermore  
Lawrence L. Beebe Paul R. Llewellyn  
Otto S. Beyer Wm. G. Lockwood  
R. E. Bishop Chas. F. Long  
Kenneth B. Blake Fred'k A. Lovell  
Ross C. Blanchard F. J. Lyon  
P. W. Bliss Wm. H. McAdams  
Geo. W. Blossom A. G. McChesney  
V. L. Bohnson Thos. T. McGovern  
J. H. Bogart David J. McGrath  
A. Bolenbaugh Wm. J. McKenna  
Dale M. Boothman Wm. S. McKinney  
Carl G. Bopp Leonard Macomber  
Paul H. M. P. Brinton Wm. C. Martin  
Nath'l B. Brodhead Robt. B. Meckley  
Wm. E. Brophy R. P. Melendy  
H. E. Bruce Hamilton Merrill  
Arthur R. Burns Hudson C. Millar  
Horace G. Byers R. W. Millar  
Samuel A. Byrne John H. Northrup  
Sidney M. Cadwell Geo. G. Oberfell  
M. U. Campau G. A. Parks  
Paul M. Carleton L. W. Parsons  
Charles H. Chaar Stuyvesant Peabody  
Charles C. Chalfant Chas. H. Pearce  
Henry P. Chandler Raymond V. Puff  
Richard M. Clucas R. R. Renshaw  
Wm. H. Coburn Jos. C. Richardson  
Chas. B. Colby Wm. M. Rile  
W. H. Coleman O. E. Roberts  
Lester C. Cover Wm. O. Robinson  
Ralph H. Crocker Geoffrey M. Rollason  
Lowell E. Dana Hugh W. Rowan  
Thos. J. Dee John D. Rue  
S. J. Delancy Jos. B. Russell, Jr.  
Arnold C. Dickinson E. K. Ruth  
Marion G. Donk Berthold E. Schlesinger  
Levi B. Duff Victor B. Schmidt  
Frank R. Flood John S. Selfridge  
Harold B. Foster Harold C. Sharpe  
Lester E. Fulford Edmund J. Shutuck  
H. L. Garner George Edward Shaw  
Paul M. Giesy Charles V. Sheehan  
Benj. Gill Jos. E. Silver  
William S. Godfrey Raymond T. Smith  
Robt. D. Gordon Frederick H. Smyth  
Robt. C. Gowdy Edward L. Stapleton  
Robert McC. Graham Leslie T. Sutherland  
Caswell Graves Godfrey M. S. Tait  
David P. Taylor

Winfield S. Grove  
Harold G. Guiteras  
Ralph R. Hall  
H. S. Harned  
Clarkson E. Harshberger  
Fred L. Hayden  
Wayne Herkness  
Michael Y. Heath  
Wilyn Herbert  
Erle C. Herman  
William H. Hickin  
Wm. E. Hoffman  
Ben. Jenkins  
Wm. De'Y. Kay  
A. W. Kenney  
Waldemar Kops  
Richard L. Kramer

Red'd E. Taylor  
M. C. Teague  
Thos. E. Thompson  
Benj. H. Throop  
Harland L. Trumbell  
Roy H. Uhlinger  
Stuart D. Warner  
Harry E. Wells  
L. G. Wesson  
Thorne L. Wheeler  
H. D. Whitehouse  
Chas. M. Whitlock  
J. A. Wilkinson  
Herbert Winkelmann  
James S. Wolf  
Alfred W. Wood  
Burnett Wright

## FIRST LIEUTENANTS

Abrahams, Clinton D.  
Abrams, Allen  
Adams, James F.  
Andrus, Leanonard A.  
Armstrong, Charles D.  
Arnold, H. C.  
Ashe, Lauron H.  
Ashman, L. A.  
Ashman, L. H.  
Ayer, Paul P.  
Bailey, Albert E.  
Beal, William D.  
Bear, H. K.  
Becker, Hasen K.  
Bedford, Edward T.  
Bell, Thomas R.  
Bennett, H. S.  
Best, Arthur F.  
Bogue, Joseph C.  
Boon, C. J.  
Brumlet, Hubert B.  
Bristow, James J.  
Brock, Earle A.  
Brodesser, R. E.  
Brown, Carl H.  
Brown, Lester B.  
Burt, R. A.  
Cahill, Michail  
Callemon, Clarence B.  
Clark, S. C.  
Clarke, Theodore  
Clifford, C. W.  
Cochran, Marshall G.  
Coghlan, S. R.  
Colebrook, M. W.  
Colotte, W. R.  
Conohay, John R.  
Cox, Samuel F.  
Crossfield, Albert S.  
Cuff, James B.  
Dasher, Frances W.  
Davidson, A.  
Davidson, Joseph G.  
Davis, George W.  
Dunbar, Noel S.  
Dwyer, C. E.  
Eason, Harry M.  
Eaton, Harry A. F.  
Eldon, John A.  
Eldridge, Arthur C.  
Elliott, Lowell A.  
Elsey, Alden G.  
Emory, Stuart R.  
Esser, Alvah E.  
Fairbanks, Herbert S.  
Fairchild, Tappan  
Felsing, W. A.  
Fitzgerald, Heber D.  
Fleming, Walter F.  
Frederick, E. L.  
Fuller, E. W.  
Gage, Roscoe M.  
Gaines, O. I.  
Gibson, Richard  
Gruse, William A.  
Gurney, Harold P.  
Hartshorn, E. B.  
Hayden, E. M.  
Henderson, L. M.  
Heneage, Thomas H.  
Hentz, William A.

McNeil, Winfield I.  
McWilliams, John C.  
MacConnell, John G.  
MacDonald, Alexander D.  
MacNeill, N. M.  
Mahlman, Osburn L.  
Manning, Edwin C.  
Mansur, Charles I.  
Marshall, William D.  
Martin, H. A.  
Mayer, Gustave  
Mayham, Ray E.  
Merrill, Leslie M.  
Merryman, James R.  
Mitchell, John H.  
Moffitt, H. R.  
Morawski, Frederick  
Morgan, A. M.  
Mott, John  
Moulton, Paul B.  
Mueller, William A.  
Mulford, William J.  
Murphy, Alfred L.  
Murtfeldt, W. Scott  
Nasseit, Harry B.  
Noble, Edson J.  
Norlin, F. C.  
Northrup, William C.  
Norton, F. A.  
O'Brien, Bernard  
Ott, J. E.  
Patterson, G. P.  
Perkins, Granville A.  
Perrett, G. St. J.  
Phillips, George W.  
Pierce, Edward T.  
Pratt, Francis S.  
Prentice, Philip B.  
Procoter, William R.  
Pyle, David H.  
Racicot, P. A.  
Rahn, Reinhard  
Ranson, William J.  
Rapee, Frank J.  
Rector, Thomas N.  
Regan, Edward F.  
Reiling, Howard A.  
Riddell, John F.  
Rixey, Eppa  
Rogers, Rollins W.  
Tomlily, Edgar P.  
Royce, Harrison S.  
Russell, G. P.  
Rutledge, George F.  
Sampson, Ernest  
Sawders, J. C.  
Scery, J. W.  
Schaufele, H. J.  
Scheirz, E. R.  
Schmidt, Mott B.  
Schultz, Addie D.  
Schwarz, M. W.  
Shaw, Guthrie  
Shaw, Joseph T.  
Sibert, Eugene  
Silsbee, James A.  
Smith, Lawrence W.  
Smith, Lee I.  
Smith, Leslie D.  
Smyth, C. P.  
Spaulding, E. G.

Hetherington, George F.  
 Hillery, Harry M.  
 Hobson, H. T.  
 Hoguet, Rene  
 Holland, Martin A.  
 Holm, George E.  
 Holmes, Raymond M.  
 Hooper, Noel J.  
 Horton, Winthrop S.  
 Howe, Robert A.  
 Howlett, Arthur E.  
 Hudson, H. H.  
 Hudson, W. E.  
 Hull, Edwin J.  
 Iddles, Alfred  
 Jackson, William M.  
 Johnson, Robert L.  
 Jones, Spencer L.  
 Katz, Sidney H.  
 Keller, Alexander W.  
 Kellogg, Edward A.  
 Kempton, Robert E.  
 Kerns, J. T.  
 Kerr, George M.  
 Klauber, Murray  
 Kientle, R. H.  
 King, Arthur G.  
 King, John L.  
 King, T. S.  
 Kipka, Ross E.  
 Kirkpatrick, Walter M.  
 Kolden, Dudley F.  
 Lamb, Lloyd B.  
 Lambert, Marion L. J.  
 Latson, Frank W.  
 Leavitt, George F.  
 Lee, Elwood B.  
 Lewis, Walter H.  
 Leyden, James, Jr.  
 Lloyd, Edward C.  
 Long, David R.  
 Long, Howard A.  
 McBride, George H.  
 McCoy, John G.  
 McCune, J. S.  
 Spriggs, C. I.  
 Staples, Scott D.  
 Steenken, F. L.  
 Steinbach, E. S.  
 Stephens, Charles W.  
 Stupp, John G.  
 Swanson, F. J.  
 Suydam, John R., Jr.  
 Talbot, John C.  
 Talcott, Harrison W.  
 Thomas, Richard W.  
 Todd, William T.  
 Towler, Thomas W.  
 Trenkman, Frederick  
 Truax, Harold W.  
 Trubee, William E.  
 Tuttle, Neal  
 Urquhart, George R.  
 Van Doren, Lloyd  
 Vile, Norman B.  
 Vincent, Max G.  
 Visscher, Raymond  
 Wallace, E. S.  
 Walsh, James F.  
 Wangler, Albert F.  
 Warden, Edward W.  
 Watson, Warren M.  
 Weeks, Robert W.  
 Weinert, R. E.  
 Wells, Arthur G.  
 Welsh, Thomas W. B.  
 Wemple, Holland R.  
 Whetzel, Joshua C.  
 Willis, Oliver E.  
 Wilson, John E.  
 Wilson, Otto  
 Winter, Edwin M.  
 Wiswall, Paul N.  
 Withington, Lathrop  
 Woodbury, Horace G.  
 Woodruff, William W.  
 Woodward, Paul G.  
 Yablick, Max  
 Yoe, John H.  
 Zimmerman, Joseph  
 McCurdy, Philip R.

## SECOND LIEUTENANTS

E. C. Bangs  
 W. H. Barrho  
 Edmund D. Barren  
 J. F. Battley  
 Arthur F. Benton  
 Fred Biance  
 J. F. Blank  
 Frederick F. Blicke  
 Roland R. Bliss  
 Robert S. Bly  
 Roland S. Beardman  
 Archibald F. Borbeck  
 Paul C. Bowers  
 Almond N. Bowes  
 Lee Bowman  
 Raymond G. Brown  
 John R. Carry  
 Arthur E. Case  
 John H. Chaplin  
 Roy C. Charron  
 Ernest M. Clark  
 John M. Diven  
 J. B. Donoho  
 J. S. Dunn  
 John S. Duckworth  
 A. D. Ellison  
 Spencer D. Embree  
 W. H. Emmons  
 H. B. Fannan  
 S. R. Funsten  
 Jeremiah D. Giles  
 R. R. Greninger  
 Paul M. Gross  
 William A. Hammond  
 Walter J. Harper  
 John R. Heath  
 Oden C. Heffner  
 Ralph Heidingsfeld  
 Ralph W. Heins  
 Harrison P. Hood  
 W. J. Huff  
 Selwyne P. Kinney  
 Walter F. Kunkle  
 Gaston J. Levy  
 Walter S. Lindsay  
 Edward H. Loeb  
 Clyde McKenzie  
 Howard B. McLane  
 Lowell H. Milligan  
 Herbert E. Moore  
 John W. Oamer  
 John B. Overstreet  
 C. W. C. Page  
 Robert N. Pease  
 Harold A. Pelton  
 F. Joel Penfield  
 Richard Penfield  
 F. C. Perkins  
 Francis W. Pettengill  
 E. J. Probeck  
 John G. Rees  
 S. Joseph Reichert  
 Lloyd H. Reyerson  
 George C. Richardson  
 William B. Ross  
 Henry A. Rothchild  
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## Quicksilver in California

Editorial Correspondence  
FOREIGN COMPETITION

THE conference between the United States Tariff Commission and producers of quicksilver held recently in San Francisco brought out very strikingly the handicaps we are working under as compared to Spain. In the latter country, government-owned mines operated by contractors using convict labor are producing metal from orebodies worked for centuries, and still yielding large quantities of 7 per cent ore. Even considering their crude methods—it is said that a Peruvian furnace built in 1634 is still being used—their production is estimated to cost no more than \$16 per flask of 75 lb., and thus dominates the world-market. At any rate their contract with the Rothschilds' London house to sell their product at not less than £7 per flask nets them a very handsome profit at the minimum price.

In the United States, on the other hand, the deposits are small, irregular, and normally of low grade. While there are some mines which have never entirely shut down since their discovery about 1850, and some containing relatively rich ore, the industry steadily declined for several years immediately preceding the war. At that time a sudden inflation and violent fluctuations resulted in the price finally being fixed at \$105, an increase of 150 per cent over the normal. This induced the opening of many prospects, but 90 per cent of the increased output still comes from companies operating four years ago. However, the grade of ore is very low, the New Idria in San Benito County, California, which is America's greatest quicksilver mine, now treating ore containing but  $6\frac{1}{2}$  lb. mercury per ton. The Sulphur Bank Association in Lake County, California, is steam-shovelling old dumps and surface workings containing no more than  $1\frac{1}{2}$  lb. metal per ton, which may be considered the present minimum limit for profitable extraction. Generally speaking, the average American ore mined today contains about 5 lb. of quicksilver per ton, that is to say, a metal content of 0.25 per cent, as compared to 0.85 per cent mined in Austria, 1 per cent in Italy and 7 per cent in Spain.

### CONCENTRATION AT NEW IDRIA

Such lean ore seems to offer a promising field for modern concentration methods. Indeed, many miners and metallurgists have attacked the problem recently despite the dictum of the older operators that "you can't concentrate quicksilver ores." The sulphide cinnabar has a specific gravity of about 8.0 as compared to that of 4.2 of the easily-treated calcopryrite. It has been demonstrated that if the cinnabar is massive and crystalline, and stage-crushing be carefully done to avoid sliming the very friable mineral, very good recoveries (up to 86 per cent) may be obtained on tables working with classified and deslimed sands. On the other hand, if the ore has been ground so as to slime the cinnabar, the values float in suspension like "paint," and are not recoverable on table, vanner, or flotation machine. Under such conditions the recovery may easily fall to 60 per cent or even lower.

Thus a well equipped and carefully controlled operation is essential to success, and it is not surprising that

the many mills which were hurriedly installed a couple of years ago at the height of the fashion are generally abandoned. Two, which are probably the largest in California, are still in operation—one at the New Idria treating 300 tons daily, and another of 350-ton capacity treating Sulphur Bank ores. According to Mr. H. W. Gould, general superintendent of these properties, even these mills are economically unjustified, and their closure is imminent. A brief description of the flow sheet at New Idria, however, may be worth while (Fig. 1).

The ores are dumped over a grizzly into the mill bins, from whence they are drawn on a belt conveyor to a  $\frac{3}{4}$ -in. trommel. The oversize enters a  $7 \times 6$  ft. Allis-Chalmers granulator ball mill with a screen discharge, the ground material entering a 6-cell Richards hydraulic classifier. Each cell of this classifier supplies feed for

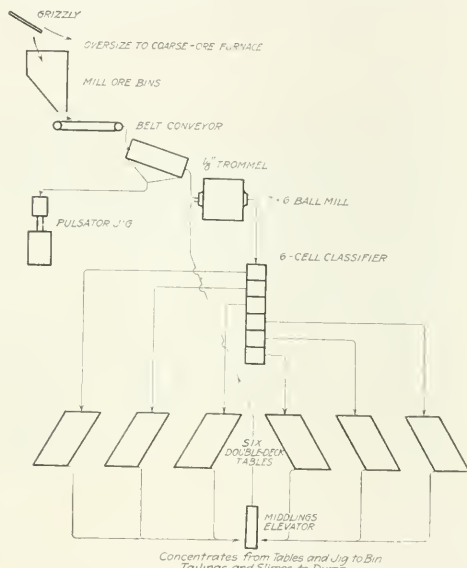


FIG. 1.—FLOW SHEET OF NEW IDRIA MILL.

one of a battery of six double-deck Deister sand tables. The table tailings, together with the considerable quantity of valuable slimes, go to the dump; the concentrates, containing perhaps 70 per cent of the values, to bins; while all middlings are returned by elevator to the head of the system for regrinding and retreatment.

The conditions at Sulphur Bank are quite unique. Here, as already noted, a steam shovel loads motor trucks with ore from old mine dumps and upper workings averaging only  $1\frac{1}{2}$  lb. of mercury per ton. These trucks dump their load on a  $1\frac{1}{2}$ -in. grizzly—all oversize is wasted, as the bulk of the values is in the fines. The undersize is drawn from a storage bin by a mechanical feeder into a long trommel with various openings ranging from 1 in. to about 20 mesh. All portions  $\frac{3}{4}$  in. and coarser are separately stored for future rehandling, while the material from  $\frac{3}{4}$  in. to 10 mesh is roughly concentrated in a single compartment jig. Material finer than 10 mesh is classified, the sands being con-

centrated in Deister-Overstrom tables and the slimes on Frue vanners. The total recovery in this mill, owing to the peculiar conditions surrounding its operation, possibly does not exceed 30 per cent; all slimes and sand-tailings are carefully stored, however, for future treatment. In this manner the concentrator acts as a device to skim the cream from the feed—to get some concentrates ranging in richness from 3 to 50 per cent for quick recovery of the metal at a period of high price and insistent demand.

#### ECONOMICS OF CONCENTRATION

This probably is the present function of concentration of quicksilver ores; to get a little rich material to mix with the coarser low-grade furnace-feed so as to increase the mercury output of present furnace and condenser equipment. The calcining of the ores is simple, efficient and cheap, costing not more than 75 cents per ton, and it is doubtful if the cost of modern concentration in small isolated plants can approach that of furnacing, even considering the much lower fixed investment in the mill per ton-day capacity. Added to this is the variation in nature of the different small ore deposits, each requiring close study to effect good recoveries—one will slime excessively during crushing, another may refuse to act satisfactorily in a flotation machine, another may be very costly to grind. These difficulties have converted many milling enthusiasts to the attitude of the "old timer." In other words, decreased costs may better be expected through increased efficiency in mining, which is three times as expensive as the subsequent metallurgical treatment.

A possible field for concentration is in connection with the development of a new prospect. Here the mineral indications might not warrant the building of an expensive furnace plant—indeed, the operators might readily lack the required capital—but a small crushing and table or flotation plant could easily be installed which would produce a concentrate worthy of shipment. As the orebody is developed, the returns from the ore will provide the funds for a local calciner, when the old mill can be discontinued and the raw ore together with the mill slimes and tailings smelted. Certain peculiar types of ore may be developed which are evidently concentrating propositions par excellence. As an example, the Black Butte Mercury Mining Company in Lane County, Oregon, has a peculiar soft ore which crushes very easily and floats very well, reducing the costs to a minimum.

#### MERCURY FURNACES

Concentrates, or very rich, fine ores in small quantity, are best treated in retorts. In its most simple form, such a furnace consists of a horizontal row of up to a dozen 12-in. iron pipes, closed at the rear with a tight removable plug, and the front fitted into a condenser, which may be merely a water jacketed 3-in. pipe, 7 to 10 ft. long. The muffles themselves may be entirely bricked in, and heated by flues leading underneath and above, leading from a wood-burning fire box or oil-flame at one end. The retorts have a small capacity, handling perhaps 150 lb. of rich ore or 75 lb. of concentrates (plus the necessary lime) per shift. Condensation of fume is easiest, since only in this type is the volatile

mercury uncontaminated by the products of combustion.

Coarse low grade ore, 3 to 9-in. lumps, on the other hand, has long been treated in vertical shafts resembling lime kilns of round or oblong cross-section. In order to prevent top-losses, a bell-charging device is desirable, the vapors being drawn off at about 200 deg. C. through down-comers just below, or through multiple openings in the shaft walls. The calcined ore is removed from the bottom at a temperature around 600 deg. C. and calcination is effected by fire-boxes located just above. These furnaces are very economical of labor and fuel, requiring one cord of wood for 20 tons of ore, while a rectangular oil-burning shaft at New Idria has been treating from 25,000 to 30,000 tons of ore per year at a total cost of somewhat less than 50 cents per ton. Since the "furnace gets it all" in the words of the operators, one readily sees what stiff competition any scheme of concentration would encounter in these calciners.

#### SCOTT FURNACE

Perhaps 75 per cent of the American production in recent years has been obtained from finer ore treated in the Scott furnace, an improved Hasenclever furnace developed by Hüttner, Scott and Randol at New Almaden in 1875. As is perhaps well known, the Scott furnace is a rectangular block of brickwork with combustion chamber at one end and a fume chamber covering the end opposite. Between the two and leading from front to back are a series of parallel vertical slots, perhaps 20 in. wide, open from the top, where ore is charged, to the bottom where it is withdrawn. In its passage through the furnace, however, the ore rests on 30 or more deflecting shelves (Fig. 2) inclined downward at 45 degrees alternately from right and left wall,

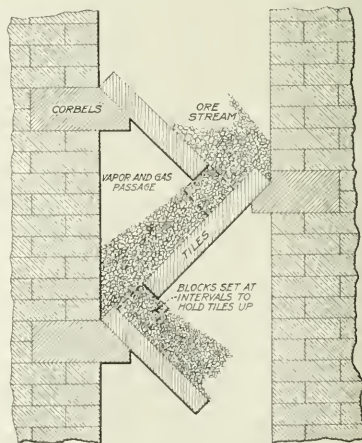


FIG. 2.—CROSS-SECTION SHOWING CONSTRUCTION IN SCOTT FURNACE

made of a line of 15 x 3 x 36-in. tiles. The tiles are set so that a slot of about 5 in. is left between the lower edge and upper surface of each succeeding pair of tiles, which slot is kept sealed by the descending ore stream. Furnace gases use the space between the top of the ore

and the bottom of the tile immediately above as a flue, heating the thin bed of slowly descending ore and volatilizing its mercury content.

The capacity of the furnace is evidently a function of the length and the output of the mine it serves. It is commonly built of 75-ton capacity, with locally-made red brick for condensers and furnace masonry, and its cost is commonly quoted at \$1000 per ton-day capacity. Dry granular ore fed to the top remains in the furnace about 24 hours before being drawn off below, during which time its temperature progressively increases to perhaps 1000 deg. C. Naturally, proper firing is an essential, 5 to 6 gallons of fuel oil or 0.03 to 0.05 cords of wood per ton of ore being required. This could be somewhat reduced, and an increased efficiency in the condensation system attained by more careful firing and narrow regulations of excess air of combustion. As it is, the cost of treatment is quite low—70 to 80 cents per ton, exclusive of interest and repairs, which latter are quite extensive at intervals of perhaps three years.

#### FURNACE RECOVERY

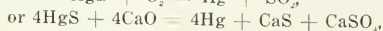
Metallurgically, the Scott furnace is a very efficient machine. As determined by Dr. L. H. Duschak of the Bureau of Mines, the top losses are extremely low, owing to the effective seal made by the fine ore. In one case it amounted to about  $\frac{1}{2}$  lb. of mercury per day in a 50-ton furnace. The calcined ore contains only a negligible amount of values; under good operation it assays as low as 0.02 per cent, while ordinary care will produce a cinder with 0.07 per cent Hg. Losses of metal as uncondensed vapor escaping up the stack have generally been considered most serious, but Dr. Duschak shows that if 75 tons of 0.7 per cent ore is burned with the usual excess air of combustion, and the resulting gases cooled to 40 deg. C., the uncondensed vapor will amount to only  $4\frac{1}{2}$  lb. of mercury. The stack losses of fine fume are practically zero if the gases are cooled with a water spray; this water of condensation in turn dissolves some acid but very little metal, and its floating content of floured mercury can be reduced by proper settlement or recovered during re-use. Altogether, the furnace extraction under good management may very readily exceed 90 per cent. As a matter of fact, average practice bottles no more than 75 per cent of the mercury in the ore. (Mercury "hangs up" in the condenser system in excessive measure—at one well-conducted plant a monthly metallurgical balance showed recoveries ranging from 60 to 130 per cent.) Definite figures are difficult, if not impossible, to obtain, for few plants make any serious effort to sample and weigh the ore as it is fed, nor account for any metal in process except that actually shipped. A leaky system operating at slightly greater than atmospheric pressure may lose much vapor at the joints. This is entirely overcome, however, by maintaining a slight suction at all times by stack or fan draft.

The most important apparent loss is in the absorption of metal by the brickwork and foundation. This is very difficult to estimate and is not considered an ultimate loss as the mercury so absorbed is largely recovered when the plant is dismantled. It is an important factor in a new plant, since, by tying up a

considerable amount of metal, it has the effect of increasing the capital investment required at the commencement of operations. In periods of abnormal prices, furnaces have been frequently dismantled to recover this mercury—a practice not consistent with good metallurgy, but often financially advisable. As much as 1000 flasks is reported to have been produced by the tearing down of a single furnace and condenser system, and old furnace sites have been excavated to a depth of 35 ft. before reaching earth not carrying visible beads of "quick."

#### MECHANICAL ROASTERS

Metallurgically the process of extracting mercury from the ore is quite similar to the roasting process practiced in large measure elsewhere, the reaction induced by extraneous heat,



taking place above the boiling point of mercury (360 deg. C.). It is only natural that roasters of the Herre-

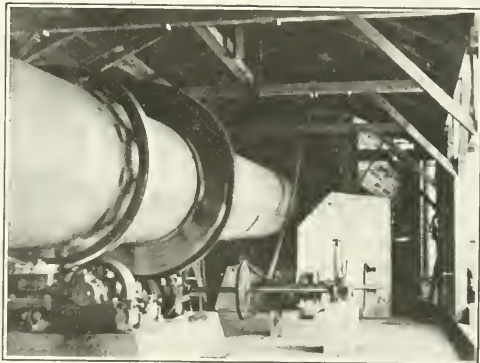


FIG. 3.—ROTARY QUICKSILVER FURNACE AT NEW IDRIA

shoff type so successful elsewhere should be tried, as has been done at New Almaden, where one treats 45 tons of  $\frac{3}{8}$ -in. ore daily.<sup>1</sup> The sulphur in the ore is insufficient to provide much of the required heat, so extra fire boxes are installed. A high consumption of fuel (8 gal. oil per ton) is required, owing to the radiation through the relatively thin walls, and an excessively dusty gas is made. This is treated while at 600 deg. F. in a Cottrell electrostatic precipitator, the gas then cooled and the mercury condensed in ordinary chambers, the cold effluent of which passes through a second cold Cottrell treater, which actually collects a vanishingly small amount of mercuric mist. At this plant a very large Scott furnace has recently been installed of 90 tons daily capacity, which produces a clean vapor with  $\frac{2}{3}$  the fuel consumption—this of course being a simpler and more desirable combination than the mechanical roaster.

H. W. Gould of the New Idria Company has recently tested a 4 x 50-ft. rotary furnace with very promising results, so much so that a second 5 x 56-ft. furnace was later installed, and four more are under order. The fur-

<sup>1</sup>See W. H. Landers, *E. & M. J.*, Oct. 7, 1916, p. 631.



nace, which is shown in Fig. 3, is like an ordinary cement kiln, receiving ore at the upper end, coned slightly to keep the discharge free of material. The furnace is fired not enough so that the entire lining is at a temperature of more than 350 deg. C., thus preventing any metal absorption. The first furnace treated 95 tons of 14-in. ore daily, or 70 tons of 1½-in. ore: probably ¾ to

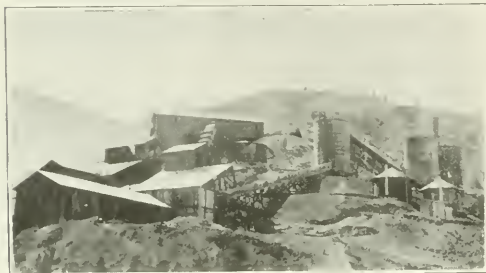


FIG. 4—WOODEN CONDENSER TANKS AT NEW IDRIA

1-in. size will be most desirable, the ore remaining in the furnace from 15 to 30 min., depending upon the volume of the ore stream, and leaving at a temperature of over 900 deg. C. in a mercury-free condition. The further advantages of this rotary furnace are its low first cost, being one-quarter to one-half that of older types, and its low consumption of fuel, while the automatic feed and discharge cuts attendance charges to a minimum.

Condensation problems have been attacked at this plant with notable success, as well. The hot dusty gases first enter a brick dust chamber of considerable volume at the end of the furnace, where the solid particles largely settle. The gases, still at 300 deg. C. or more, then pass through a flue made of 18-in. sewer tile into the first wooden tank shown in Fig. 4, 20 ft. in diameter and 30 ft. high. Several sections of this tile flue have side outlets, through which a tile bend enters, open to the air at the outer end and the inner turned in the direction of the gas stream (Fig. 5). Fixed at the end of the tile bend is a water spray which not only cools the hot gases by its evaporation, but sucks outside air into the flue by injector action. The result is that the hot dry gas leaving the brick chamber enters the wooden condenser saturated with water vapor and at about 80 deg. C. During the passage through the three condensers shown in Fig. 4, the gases further cool to 40 or 50 deg. C., depositing practically all of their mercury and much of their water—the bulk collecting in the first tank. The condensers themselves are placed several feet above a concrete basin, and the mercury and water withdrawn periodically through valve-controlled drain pipes. Very little soot is formed in this installation, thus warranting the discontinuance of their rather elaborate soot-mill.

The advantages of this condenser system are obvious. Wooden tanks are very easily and cheaply built and kept air tight, metal absorption is very low, clean-ups may be readily effected by merely hosing down the walls, the metal is withdrawn without the dangerous necessity of entering the condensers, and there are no dead spaces for sulphuric acid and mercury gases to eddy about and combine. Mr. Gould and his associates are

to be congratulated on this very evident advance in the art of getting quicksilver.

The expected consumption of quicksilver in the United States during the year 1918 was estimated in April by Mr. F. L. Ransome, of the U. S. Geological Survey, as follows:

|                                                           | Flasks |
|-----------------------------------------------------------|--------|
| Drugs and chemicals, largely calomel and dental amalgams  | 12,180 |
| Fulminate for detonators                                  | 12,218 |
| Antifouling ship-paint (red oxide)                        | 2,905  |
| Vermillion (mercuric sulphide)                            | 1,900  |
| Electrical uses in rectifiers and vapor lamps             | 2,687  |
| Felt making (mercuric nitrate)                            | 1,800  |
| Amalgamation of gold and silver ores                      | 800    |
| Thermometric, barometric and other scientific instruments | 676    |
| Boiler feed-water treating compounds                      | 700    |
| Cosmetics                                                 | 300    |
| Total                                                     | 36,166 |

The mines of the United States could probably easily supply this amount if our exports were discontinued, since the production in 1917 amounted to 36,351 flasks. Great activity in production is necessary, however, since some of the manufacturers of fulminates have but recently received largely increased estimates of requirements for the army and navy, one estimate demanding more mercury than the entire total above given.

In case of an acute shortage, many of the uses could be considerably curtailed, either by non-supply or by substitution. For instance, cosmetics, water treating compounds, felt making, and vermilion could largely be foregone, temporarily. Miscellaneous chemicals could be sharply curtailed, as well. Substitutes for fulminate, were largely imported from Germany prior to the war and were used in blasting caps, replacing a large amount of fulminate when mercury was at prices above \$40. These imported compounds are now about

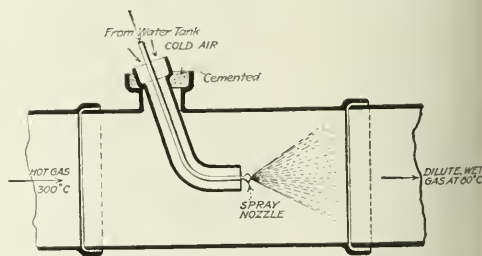


FIG. 5.—TILE FLUE FOR COOLING MERCURY VAPOR

exhausted, and their methods of manufacture are unknown—American-made substitutes require fulminate to detonate them, and may cut down the mercury consumption about 75 per cent. It is understood, however, that at present prices of substitutes it is cheaper to use pure fulminate when mercury is at \$75 and probably even at the present \$105. As to their reliability of operation, it suffices to say that the ordnance departments of the allied governments will not accept substitutes in caps or detonators. This confines their use to blasting caps for mining and excavation and in the making of sporting goods. In the latter case a misfire is not so vital, while in blasting the insertion of two caps in every important shot will insure 100 per cent operation at a small relative increase in cost.

# The Metallography and Heat Treatment of Metals Used in Aëroplane Construction—III

Investigation of Parts Made from Chrome-Vanadium, Nickel, Chromium and Tungsten Steels—Causes of Failure in Piston Pins, Axles and Bolts—Physical Properties of Raw and Treated Materials

By F. GROTTES

Chief Metallurgist, Curtiss Aëroplane and Motor Corporation

## CHROME-VANADIUM STEEL

**P**ISTON pins and connecting rods are made from chrome-vanadium steel. The piston pins have a slightly higher carbon content than the connecting rods. This material, when properly heat-treated, has a very fine structure and is very tough and strong.

The defects found are manganese sulphide, slag and seams.

Connecting rod analysis: C, 0.35; Mn, 0.78; S, 0.027; P, 0.025; Cr, 0.94; V, 0.17.

Physical properties of raw stock.

|                                |         |
|--------------------------------|---------|
| Ultimate tensile strength, lb. | 136,700 |
| Yield point, lb.               | 85,200  |
| Elongation, per cent.          | 15.6    |
| Reduction, per cent.           | 45.5    |
| Brinell                        | 302     |
| Scleroscope                    | 42      |

Double quenched 1700 deg. and 1600 deg. in oil; drawn at 1200 deg.

|                                |         |
|--------------------------------|---------|
| Ultimate tensile strength, lb. | 145,000 |
| Yield point, lb.               | 135,000 |
| Elongation, per cent.          | 18      |
| Reduction, per cent.           | 62      |
| Brinell                        | 300     |
| Scleroscope                    | 48      |

Piston pins are drawn at 1000 deg. and it is essential that the greatest possible care and supervision be given them in order to get satisfactory results. Defects have been found in pins that were thought to be seams but were in reality due to faulty heat-treating. In quenching, the pins should be dropped in vertically and not tossed in indiscriminately. Oil is nearly always used as a quenching medium but hot water can be used with good results. This is similar to the conditions found under chrome-nickel piston pins where the hardening cracks occurred.

## PISTON PIN INVESTIGATION

These pins are made from chrome-vanadium steel and have an analysis of C, 0.46; Mn, 0.68; S, 0.028; P, 0.032; Cr, 1.12; V, 0.14. On being machined small hair lines appeared that resembled a hardening crack; also it was observed that some pins were very soft.

The object of the investigation was to determine the cause of the cracks which in some cases extended from end to end, and also to investigate the heat treatment.

**Procedure:** The 50 pins submitted, which were supposed to have been heat-treated, were scleroscoped and showed a hardness of 20 to 26.

Fifteen of the pins taken as representatives of the lot were heated up to 1760 deg., held 10 minutes and quenched in oil. After they had cooled, they were re-

quenched in oil at a temperature of 1600 deg., the hardness averaging 58 after the second quench.

Five of the 15 pins were drawn at 800 deg., air-cooled and showed a hardness of 53 to 55. Another 5 were drawn at 900 deg., air-cooled and showed a hardness of 49 to 52. The remaining 5 were drawn at 1000 deg., air-cooled and showed a hardness of 44 to 47.

A section taken at the crack was polished and photographed at a magnification of 100. The result is shown in Fig. 62. Another section was polished and etched

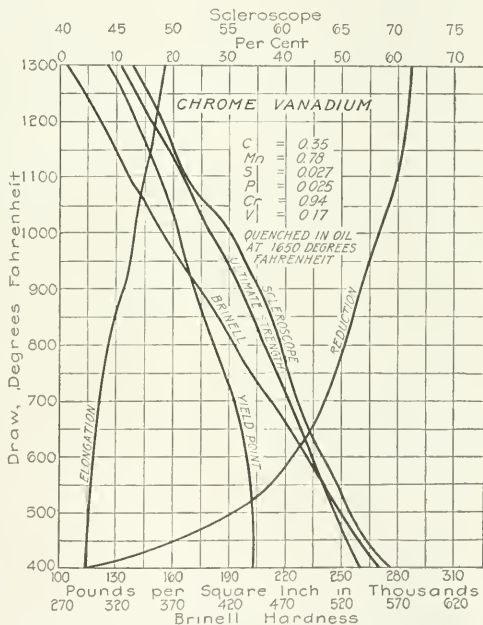
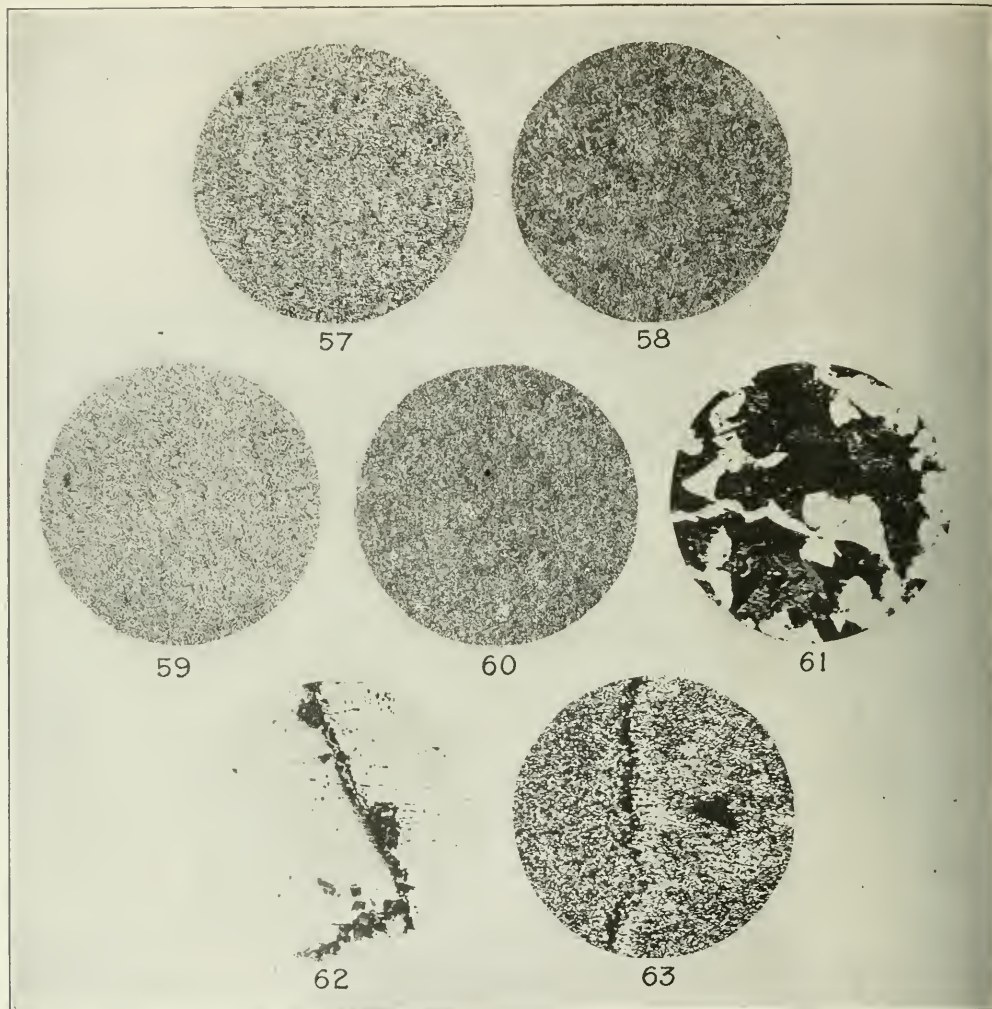


PLATE 5.—PROPERTIES OF CHROME VANADIUM STEEL

with alcoholic nitric solution, with the result shown in Fig. 63.

**Summary:** These pins when heat-treated properly give a hardness of about 50 to 55; so the treatment of these pins originally was incorrect (drawn too high). The cracks found were seams containing oxide, as shown in Fig. 62.

Fig. 63 shows how the steel was decarbonized near the seam. The structure shows ferrite with sorbite, indicating that the draw was somewhat too high, probably about 1250 deg. Fahrenheit.



FIGS. 57-63

Figs. 57-61—Chrome Vanadium Steel. Analysis: C, 0.35 per cent; Mn, 0.78; S, 0.027; P, 0.025; Cr, 0.94; V, 0.17. Etched with picric acid; magnification, x 100. Fig. 57—Quenched; 58—quenched and drawn at 800 deg.; 59—quenched and drawn at 1000 deg.; 60—quenched and drawn at 1200 deg.; 61—raw stock; 62—63—Cracks in piston pins; x 100.

### NICKEL STEEL

This is a typical pearlitic steel and one of the most important in aeroplane construction, as the nickel going into solution into the ferrite increases its strength, elastic limit and hardness, which in turn makes a stronger and harder pearlite, therefore a better steel than an equivalent carbon steel. It will stand lots of cold working in the annealed state. It is used for bolts, nuts and parts subject to shock.

The average composition is C, 0.32; Mn, 0.50; S, 0.035; P, 0.0173; Ni, 3.74.

The critical points are slightly lower than those of a same percentage carbon steel, the heating point being about 1325 deg. F. and the cooling about 1175 deg. F.

It is very susceptible to oxidation and should be

placed in boxes or handled in a reducing or neutral atmosphere when being heat treated.

#### Raw stock physical properties:

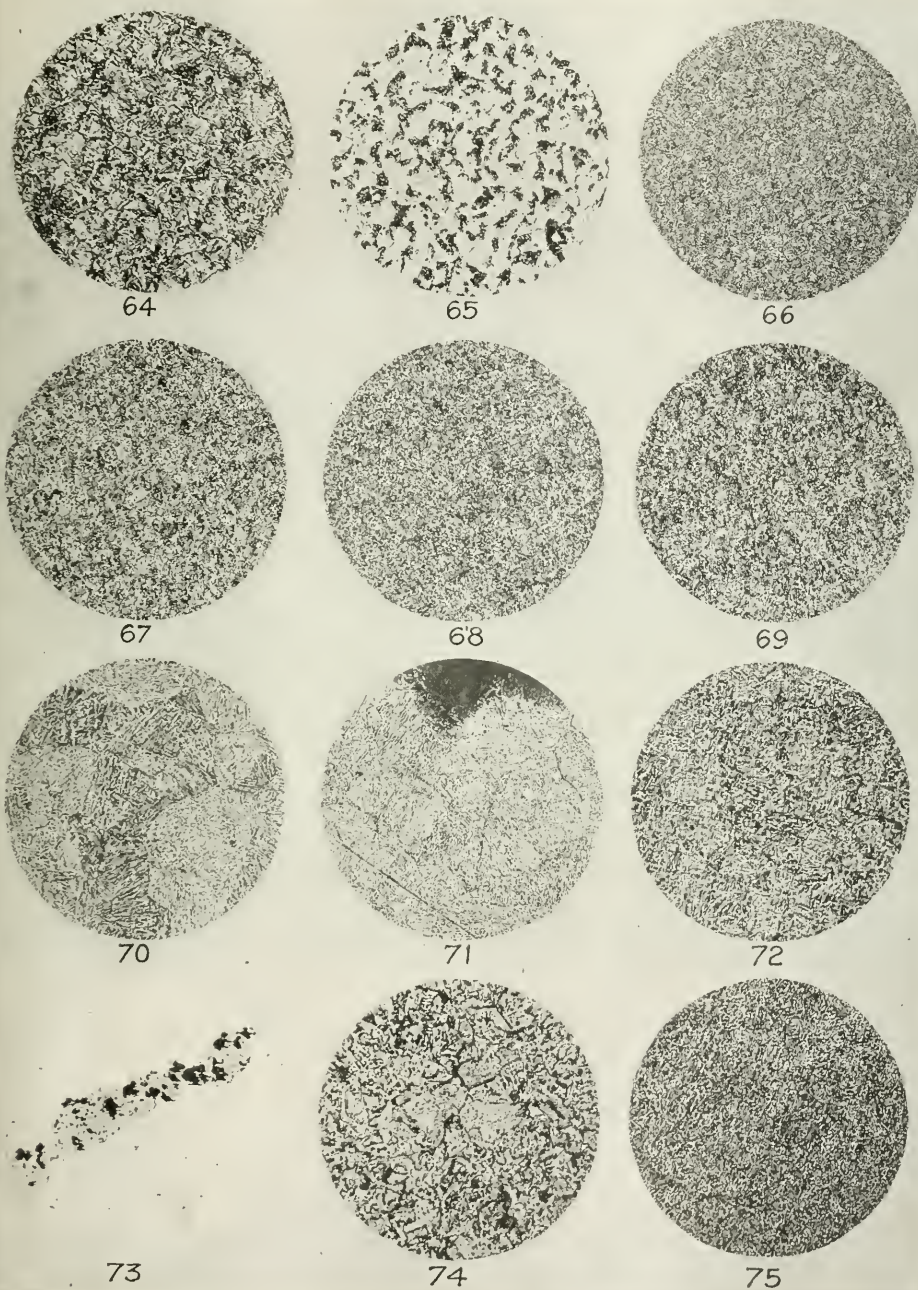
|                               |         |
|-------------------------------|---------|
| Ultimate tensile strength, lb | 112,200 |
| Yield point, lb               | 97,200  |
| Reduction, per cent           | 49.9    |
| Brinell                       | 217     |
| Scleroscope                   | 40      |

Quenched in oil at 1500 deg. F. and drawn at 1000 deg. F.:

|                               |         |
|-------------------------------|---------|
| Ultimate tensile strength, lb | 120,000 |
| Yield point, lb               | 100,000 |
| Reduction, per cent           | 65      |
| Elongation, per cent          | 20      |
| Brinell                       | 230     |
| Scleroscope                   | 38      |

The most common defects found in this stock are pipes and slag inclusions. More pipes are found in this material than in any other. Owing to the peculiar frac-



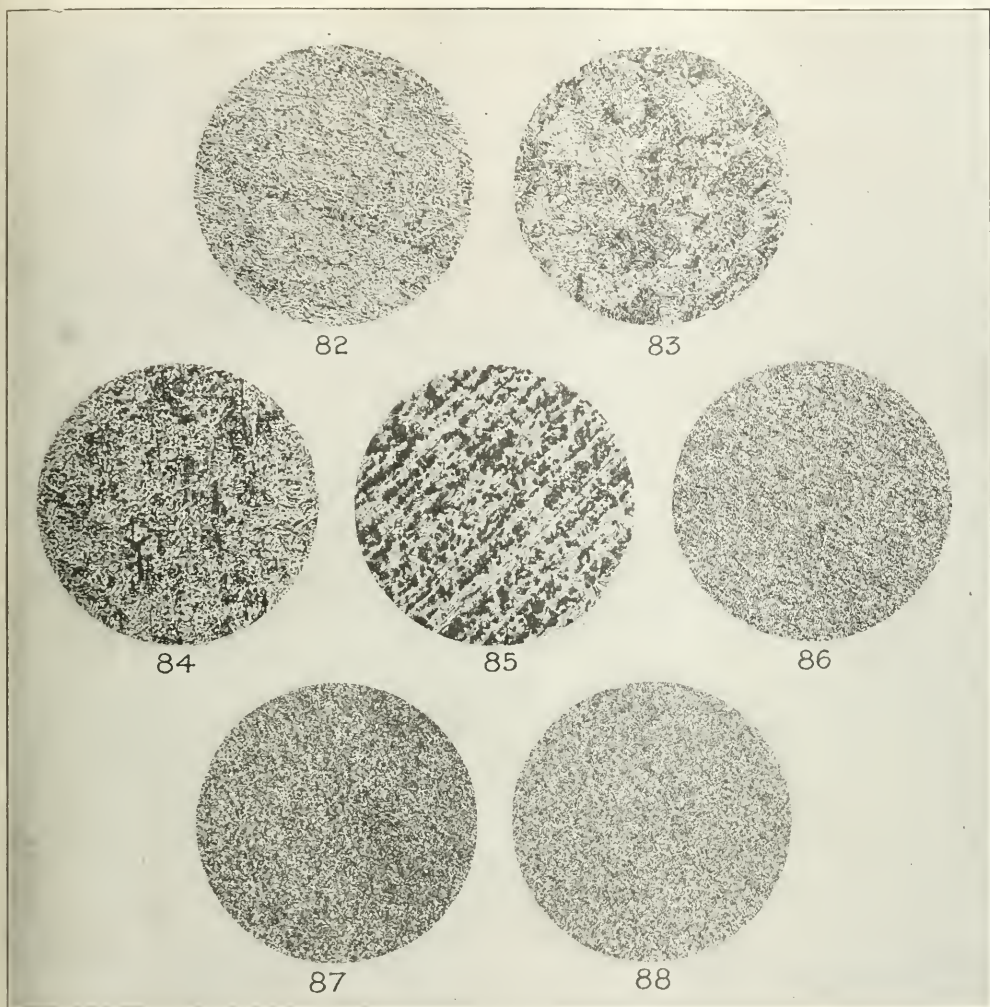


FIGS. 64-75.

Figs. 64-69—Nickel Steel. Analysis: C, 0.32; Mn, 0.50; S, 0.035; P, 0.017; Ni, 3.74. Etched with picric acid; magnification,  $\times 100$ . Fig. 64—Raw stock; 65—furnace annealed; 66—quenched; 67—quenched and drawn at 800 deg.; 68—quenched and drawn at 1000 deg.; 69—quenched and drawn at 1200 deg. Fig. 70—Nickel steel axle. Fig. 71—Surface lines on axle. Fig. 72—Axle after treatment. Fig. 73—Sand split in bolt. Fig. 74—Over-heated bolt. Fig. 75—Same, properly heat-treated.







FIGS. 82-88.

Figs. 82-85—Vanadium Steel. Analysis: C, 0.22; Mn, 0.72; S, 0.039; P, 0.04; V, 0.12. Etched with picric acid; magnification, x 100. Fig. 82—Quenched stock; 83—quenched and drawn at 800 deg.; 84—quenched and drawn at 1000 deg.; 85—annealed. Figs. 86-88—Tungsten Steel. Analysis: C, 0.47; Mn, 0.38; S, 0.025; P, 0.01; Cr, 3.15; V, 0.72; W, 15.55. Etched with picric acid; magnification, x 100. Fig. 86—Quenched in oil; 87—heated to 1950 deg. and cooled in air; 88—quenched and drawn at 1400 deg.

object of the investigation was to determine the cause of the brittleness and also to investigate the lines.

A section was taken and examined carefully, then polished, etched and photographed. This section was scleroscoped and brinelled, then drawn at a temperature of 500 deg.

Fig. 70 shows the structure and nature of the axle. Fig. 71 shows the peculiar surface lines that occurred along the length of the axle. The material as it was, scleroscoped 65 and brinelled 495; on being drawn at 500 deg. for 30 minutes, it scleroscoped 55-56 and brinelled 395-400 (See Fig. 72).

**Summary:** The investigation shows that this material was merely quenched and never drawn at all. The surface lines were folds. In the forging or rolling

of the steel, thin plates or sheets of oxide were folded in. Material that has as many folds as this should be rejected as it will certainly fail when subjected to stress or vibration. A flaw of this kind can never be improved and there is no question but that it will grow.

#### BOLT INVESTIGATION

Two parts fabricated from nickel-steel were investigated because one failed in service. A section of the one that had not had the strain of the other was polished, and photographed at a magnification of 100. It is shown in Fig 73.

This is a typical sand split and is made up principally from manganese sulphide. The sulphur prints show an abundance of sulphur. Bars that have in-



clusions of this size should be rejected, as they are unfit for use.

#### OVERHEATED BOLT

A base bolt used for holding the engine in place, on shearing in two was investigated. A section on being polished, etched with picric acid and photographed at a magnification of 100 showed as in Fig. 74. This bolt was overheated at a temperature probably of 1850 to 1900 deg. As it is, it is very soft and has no strength. Cases like this occur when couples do not register properly or when workmen sleep on the job.

Material shown in Fig. 74 was heat-treated by heating to 1525 deg., holding for ten minutes and quenching in oil, then drawing at 1000 deg. and cooling in air. It is interesting to observe in Fig. 75 that this material has been refined very nicely. Carbon steels of the same carbon content as this nickel steel when handled at the same temperatures failed to give satisfactory results.

#### CHROMIUM STEEL

This steel is particularly of value because of its non-corrosive properties. This particular steel having an analysis of 0.24 C, 0.36 Mn, 0.013 S, 0.020 P, 10.44 Cr and 0.30 V, was subjected to solutions of water, 10 per cent salt, 10 per cent sodium hydroxide and 1 per cent sulphuric acid for five days. There was no effect except

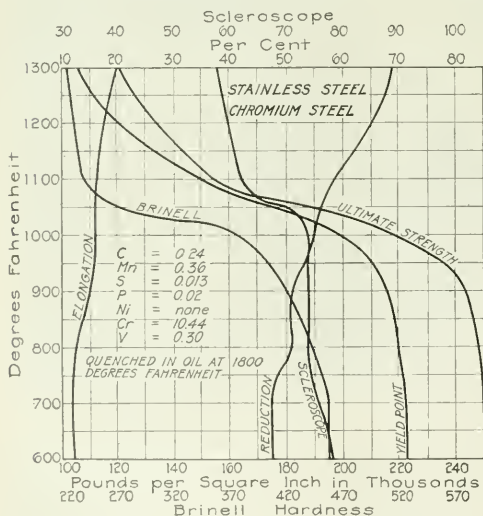


PLATE 7.—PROPERTIES OF CHROMIUM STEEL

in the case of the acid which darkened the surface of the specimen slightly.

Specimens on being quenched in oil showed that a temperature of 1800-1825 deg. gave the best results:

| Temperature | Brinell | Scleroscope |
|-------------|---------|-------------|
| 1,400       | 179     | 34          |
| 1,450       | 187     | 35          |
| 1,500       | 351     | 53          |
| 1,550       | 364     | 55          |
| 1,600       | 387     | 57          |
| 1,650       | 418     | 61          |
| 1,700       | 477     | 60          |
| 1,750       | 512     | 62          |
| 1,800       | 532     | 65          |
| 1,850       | 512     | 65          |
| 1,900       | 477     | 62          |

Quenched at 1800-1825 deg. and drawn:

| Temperature | Brinell | Scleroscope |
|-------------|---------|-------------|
| 600         | 460     | 58          |
| 700         | 460     | 56          |
| 800         | 444     | 54          |
| 900         | 425     | 54          |
| 1,000       | 380     | 54          |
| 1,100       | 248     | 42          |
| 1,200       | 241     | 40          |
| 1,300       | 235     | 38          |

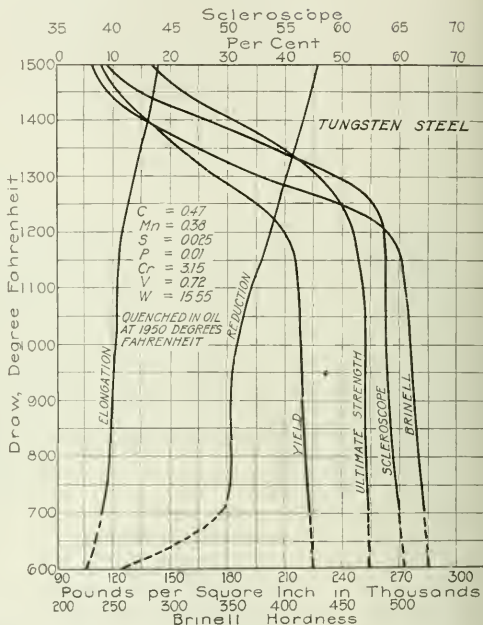


PLATE 8.—PROPERTIES OF TUNGSTEN STEEL

Physical properties when quenched at 1800-1825 deg. in oil and drawn at 850 deg.:

|                                |         |
|--------------------------------|---------|
| Ultimate tensile strength, lb. | 225,000 |
| Yield point, lb.               | 220,000 |
| Elongation, per cent.          | 14      |
| Reduction, per cent.           | 50      |
| Brinell.                       | 430     |
| Scleroscope                    | 72      |

#### VANADIUM STEEL

This steel is especially good for sheet steel that has to be fabricated into parts that are punched, e.g., machine-gun mounts, etc. It is very tough and has much better physical properties than ordinary sheet steel.

Chemical analysis: 0.22 C, 0.72 Mn, 0.039 S, 0.040 P, 0.12 V.

Quenched in oil, it gave the following results:

|                                | 1500 Deg. | 1600 Deg. | 1700 Deg. |
|--------------------------------|-----------|-----------|-----------|
| Ultimate tensile strength, lb. | 139,000   | 195,300   | 202,000   |
| Yield point, lb.               | 113,000   | 168,000   | 172,100   |
| Elongation, per cent.          | 3.00      | 4.5       | 6.75      |
| Scleroscope                    | 44        | 55        | 58        |

Quenched in oil at 1700 deg. and drawn:

|                                | 1000 Deg. | 1100 Deg. | 1200 Deg. | 1300 Deg. | 1400 Deg. |
|--------------------------------|-----------|-----------|-----------|-----------|-----------|
| Ultimate tensile strength, lb. | 124,000   | 118,600   | 106,000   | 88,000    | 75,600    |
| Yield point, lb.               | 114,700   | 105,400   | 98,000    | 76,400    | 60,800    |
| Elongation, per cent.          | 14        | 15        | 15        | 18        | 20        |
| Scleroscope                    | 38        | 37        | 35        | 32        | 28        |

#### TUNGSTEN STEEL

Tungsten steel is used for high-speed cutting tools and exhaust valves. It requires a very high temperature to harden it successfully. An interesting property

is that it may be heated to a dull red and still retain its cutting properties.

Physical properties of raw stock:

|                               |         |
|-------------------------------|---------|
| Ultimate tensile strength, lb | 110,000 |
| Yield point, lb               | 84,800  |
| Reduction, per cent           | 54.00   |
| Elongation, per cent          | 24.00   |
| Brinell                       | 207     |
| Scleroscope                   | 35      |

(To be continued)

Chemical analysis: 0.47 C, 0.38 Mn, 0.025 S, 0.01 P, 3.15 Cr, 0.72 V, 15.55 W.

Quenched at 1950 deg. in oil and drawn at 400 deg.:

|                               |         |
|-------------------------------|---------|
| Ultimate tensile strength, lb | 248,000 |
| Yield point, lb               | 225,000 |
| Reduction, per cent           | 43      |
| Elongation, per cent          | 6       |
| Brinell                       | 520     |
| Scleroscope                   | 64      |

## The Magnetic Permeability of Steel

Permeametric Measurement of Magnet Steels Used for Electrical Machinery—Value of Hysteresis Data in Standardizing and Inspecting Steel Tools—Commercial Permeameters

By FRANK P. FAHY

PERMEAMETERS are employed in the determination of the magnetic properties of materials. These properties may be considered to be defined by the normal induction and hysteresis data.

A normal induction curve, or the ascending magnetization curve,  $OAC$  in Fig. 1, is the curve determined by the plotting of points representing the values of normal induction (magnetization) reached under various magnetizing forces when the material under examination has previously been demagnetized. Magnetic induction, or flux density, is represented by the symbol  $B$ , and magnetizing force by the symbol  $H$ . The quotient  $B/H$  for any point on the normal induction curve gives the permeability or magnetic conductivity for the material under the conditions represented by that point.

If after magnetizing a specimen of material to a given value of induction the magnetizing force is decreased, the induction observed for the new value of magnetizing force does not correspond to the value previously obtained in the measurement of normal induction, but has a higher value. In other words, the descending curve of magnetization,  $CDEFG$ , shows a distinct lagging in the fall of induction with respect to magnetizing force. To finally reduce the induction to zero requires the application of a magnetizing force in the opposite direction to that originally imposed. To this lagging effect has been given the name hysteresis. The amount of lag varies with the nature of the material and the degree to which it has been previously magnetized.

The information to be derived from the normal induction and hysteresis data is of the first importance in the selection of material intended for use in the construction of electrical machinery or apparatus which depends for its efficient operation upon the magnetic characteristics of some component part. Sometimes material of high permeability and low hysteresis is required, as in generators, motors and transformers. On the other hand permanent magnet material must have opposite characteristics to the above.

The question of the magnetic characteristics of iron and steel, and necessarily the methods of measuring such characteristics, is one of importance to metallurgical chemists. The signal improvement in recent years in the magnetic quality of transformer steels is the happy result of skilled chemical and metallurgical treat-

ment. The more recent work of Yensen<sup>1</sup> on electrolytic iron melted in vacuo, which when translated into practice will mean greatly increased operating efficiency in many forms of electrical apparatus, is another case in point. The magnetic characteristics of this exceptional

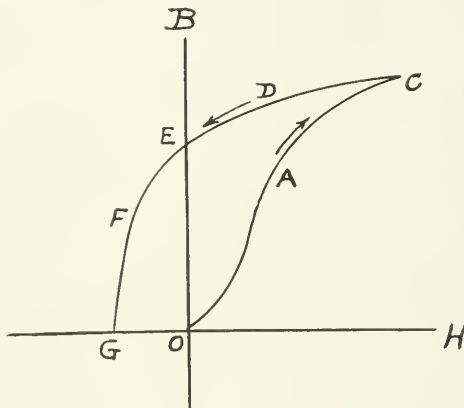


FIG. 1.—NORMAL INDUCTION CURVE

material may be modified by variations in chemical content so as to suit the material to special operating conditions.

At the present time particular attention is being given to research work on permanent magnet material. There are several reasons for this. First and foremost is the enormously increased demand for magnet steels for magneto construction. Again, a short time ago the scarcity and price of tungsten led to further investigation in the matter of substituting chrome as the preponderating alloying element. Chrome magnet steels were not unknown, but the action of tungsten being apparently more favorable to the attainment of the desired magnetic characteristics, the use of such steels was limited. While magnet steels of good characteristics are readily procurable today, it is a fact that develop-

<sup>1</sup>"Magnetic and Other Properties of Electrolytic Iron Melted in Vacuo," Trygve D. Yensen, Engineering Experiment Station, University of Illinois, Bulletins Nos. 72 and 77.

ment work along this line has lagged to such a degree that there is room for very considerable improvement. Some of the more recently developed steels have yet to be subjected to tests in apparatus known to be capable of giving accurate test results before the claim made for them may be accepted.

The present interest displayed in the subject makes it desirable to explain briefly here the meaning of some of the criteria which are used to characterize permanent magnet steels. Material intended for this purpose is practically always used in the heat-treated condition; i.e., the raw stock is hardened in oil or water from above the critical range and may or may not be drawn thereafter. Sometimes the steel, after hardening, is subjected to an ageing process, thermal in nature, which consists in heating it several times to about 100 deg. C., each heating being followed by immersion in cold water. Another ageing process subjects the material to the effects of mechanical jarring. Both of these ageing processes are intended to mature the material by effecting promptly a large part of the change which would occur in the course of time due to the secular softening of the material. This maturing or ageing is of special importance where constancy of the original properties of the magnet must be maintained.

#### THE HYSTERESIS CONSTANTS: REMNANT INDUCTION AND COERCIVE FORCE

If the magnetizing force is removed, after the material is magnetized to a high degree as  $C$ , Fig. 1, under conditions where the magnetic circuit is entirely closed upon itself, the induction falls to the value corresponding to the point  $E$ . The value of this induction, shown by the ordinate  $OE$  is known as the residual induction. If the magnetizing force is then reversed in direction and gradually increased the induction is reduced finally to zero at a value of reversed magnetizing force shown by the abscissa  $OG$ . This reversed magnetizing force is known as coercive force. Both the residual induction and coercive force must be known to properly determine the quality of material intended for use in permanent magnets, and both should be as high as possible in value. Collectively these two quantities are known as the hysteresis constants.

While the standard tests of permanent magnet material are made under conditions where the magnetic circuit is closed upon itself, the influence of joints in this circuit, being corrected for, magnets themselves are usually employed under circumstances where the magnetic circuit is open. An instance may be found in the case of a magneto, where the armature revolves between the open ends or poles of the magnet, which in this case is horse-shoe in shape. Here the circuit is made up of the magnet, two air gaps and the armature core. The open circuit modifies in an important manner the induction above designated as the residual induction, for the reason that the poles of the magnet exert a demagnetizing influence on the magnet itself which reduces the induction. We have then to consider a new term, namely, remanent induction. Remanent induction is to the open magnetic circuit what residual induction is to the closed magnetic circuit.

It is the remanent induction which serves the immediate useful purpose in a magnet, as it determines the strength of the magnet under the conditions in which it

is to be used. The loss of induction due to the open circuit, that is, the difference between the residual induction and remanent induction, depends upon the form of the magnet, the value of the residual induction and the value of the coercive force. In Fig. 2 are plotted curves for magnet steel material Nos. 1 and 2 which

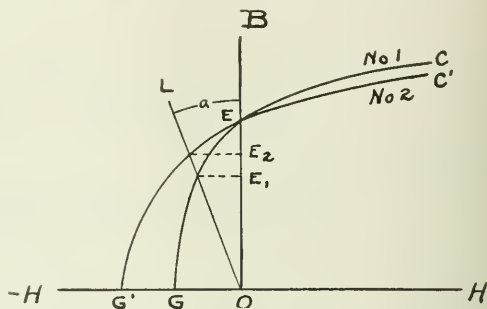


FIG. 2.—RESIDUAL INDUCTION AND COERCIVE FORCE

will assist in making this clear. The curve  $CEG$  for material No. 1 shows a residual induction equal to  $OE$  and a coercive force equal to  $OG$ ; the curve  $C'E'G'$  for material No. 2 shows a residual induction equal to  $OE'$  and a coercive force equal to  $OG'$ .

The self-demagnetizing influence may be expressed by means of a coefficient or factor which in some cases can be calculated and is always subject to close experimental determination. If we assume magnets of the same size and shape made up of materials Nos. 1 and 2, then since the materials have the same form and the same residual induction the demagnetizing coefficients will be similar. The action of this coefficient may be shown graphically by drawing the line  $OL$ , making an angle  $\alpha$  so that tangent  $a$  represents the demagnetizing coefficient. The intersection of the line  $OL$  with the curves  $CEG$  and  $C'E'G'$  determines the remanent inductions of the two magnets. From Fig. 2 it will be seen that the remanent induction of the magnet made from material No. 1 is equal to  $OE_1$ , while that made from material No. 2 is greater and is equal to  $OE_2$ . It is obvious that the value of the coercive force is the determining factor in limiting the loss of induction.

Coercive force, besides being of value in helping to overcome the demagnetizing influence, is also of assistance in counteracting the effects of severe vibration which magnets are frequently subjected to under the conditions of use. The practical importance of high coercive force therefore lies not only in its action in cutting down the loss of induction due to the demagnetizing influence but also in its action in stabilizing the remanent induction. While high remanent induction must be the chief desideratum, it will be clear that it is arrived at and maintained only by means of a high coercive force. Since the demagnetizing factors for all conditions may be determined once for all, the testing and comparing of magnet steel material may be made on the basis of measuring the residual induction and calculating the remanent induction for the particular conditions of use. The coercive force values remain unchanged whether the magnetic tests are carried out either under closed or under open magnetic circuit conditions.



The practical usefulness of magnetic data has been greatly augmented by the proof that they furnish valuable information as to the mechanical and structural characteristics of those materials which are magnetic in character, as iron and steel, but are designed for use under conditions where their mechanical stability is all-important. The limitations of the microscope and the fact that hardness and chemical tests frequently fail to distinguish adequately between materials, where the magnetic test shows distinct differences, greatly augments the serviceability of this new addition to metallurgical test procedure. Comparatively great magnetic changes accompany thermal or mechanical treatment.

Waggoner<sup>2</sup> has shown that magnetic hysteresis and the maximum strength of steels vary in the same way with changing carbon content. Gumlich<sup>3</sup> has found that the coercive force of annealed steel increases linearly with the carbon content up to the eutectic and thereafter, but at a decreased rate after the eutectic is passed. Mars<sup>4</sup> has shown that there is a definite relation between the Brinell hardness and the residual induction in a series of iron carbon alloys. Burrows<sup>5</sup> has shown the wide changes in magnetic properties which accompany changes in heat-treatment procedure.

An important application of magnetic analysis in the laboratory is in the study of those materials or tools which have given exceptional performance, in order to determine wherein they differ from the routine output. The point that the test is not a destructive one warrants individual examination of more or less expensive tools, at any stage in their manufacture. Routine examination requires of course that the magnetic criteria of a standard and satisfactory tool be established initially, and the allowable limits from the manufacturing standpoint determined.

The magnetic criteria use in correlating the magnetic and mechanical properties of materials vary according to the special problems involved. Frequently a single

are found most valuable, as these values are profoundly influenced by the existent structural and hardness conditions. Experience has shown that identical specimens of raw material when subjected to the same thermal or mechanical treatment will always have the same final magnetic characteristics. Departure from standard values established once for all for a given process of handling or manufacture, after allowance is made for practical manufacturing limitations, may be made to serve as a basis for rejection or culling.

Table I gives the results of hysteresis tests upon a lot of high-speed steel twist drills furnished under a definite chemical and thermal treatment specification. The values of the material in the annealed condition is as follows:

| Specimen No.                                      | Residual Induction | Coercive Force |
|---------------------------------------------------|--------------------|----------------|
|                                                   | 17,300             | 18.2           |
| TABLE I—MAGNETIC TESTS OF HIGH SPEED TWIST DRILLS |                    |                |
| Specimen No.                                      | Residual Induction | Coercive Force |
| 1                                                 | 7100               | 41.6           |
| 2                                                 | 7000               | 48.9           |
| 3                                                 | 6980               | 44.2           |
| 4                                                 | 6800               | 47.4           |
| 5                                                 | 7030               | 47.4           |
| 6                                                 | 7130               | 47.2           |
| 7                                                 | 7040               | 48.0           |
| 8                                                 | 7100               | 50.8           |
| 9                                                 | 7150               | 42.0           |
| 10                                                | 7000               | 42.0           |
| 11                                                | 6930               | 48.0           |
| 12                                                | 6810               | 44.8           |

Considering the rather wide percentage variation shown in coercive force and bearing in mind that "the experimental evidence seems to point to the conclusion that there is one and only one set of mechanical characteristics corresponding to a given set of magnetic characteristics," it follows that certain of the above drills differ considerably from each other. The results of the magnetic test, if compared with the results of actual cutting tests, which have not been carried out on these drills, would afford information of considerable value.

Table II shows magnetic test results for a lot of carbon steel reamers, where the variation in values of coercive force from the mean is about 44 per cent.

TABLE II—MAGNETIC TESTS OF CARBON STEEL REAMERS

| Specimen No. | Coercive Force |
|--------------|----------------|
| 1            | 24.1           |
| 2            | 26.4           |
| 3            | 30.5           |
| 4            | 21.7           |
| 5            | 29.1           |
| 6            | 21.2           |
| 7            | 30.0           |
| 8            | 33.0           |
| 9            | 33.1           |
| 10           | 25.8           |
| 11           | 27.4           |
| 12           | 27.9           |

The development of apparatus for the magnetic analysis of materials has been signally backward when compared with the advances made in the general testing appliance field. This is true when the magnetic testing equipment is designed for use in what may be called purely electrical testing, where information in regard to the magnetic characteristics of materials is demanded in connection with the design of electrical machinery. It is equally true where information is desired as to the magnetic characteristics of materials or tools, in order to determine their quality or to predetermine their mechanical performance.

Until quite recently the difficulties in the way of making rapid and accurate magnetic measurements seemed insurmountable. The general problem of making

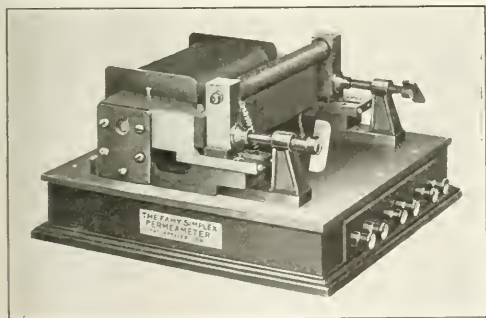


FIG. 3.—SIMPLEX PERMEAMETER

value of permeability determined under a definite magnetizing force suffices to define the state of a product, but in general one or both of the hysteresis constants

<sup>2</sup>Waggoner, "A Relation Between the Magnetic and the Elastic Properties of a Series of Unhardened Iron-Carbon Alloys," *Physical Review*, 35, pp. 58-65; 1912.

<sup>3</sup>Gumlich, "Magnetic Properties of Iron-Carbon and Iron-Silicon Alloys," *Faraday Society Transactions*, 8, pp. 98-114; 1912.

<sup>4</sup>Mars, *Stahl und Eisen*, 29, pp. 1673-1678; 1909.

<sup>5</sup>Burrows, "Correlation of the Magnetic and Mechanical Properties of Steel," *Bulletin. Bureau of Standards*, Vol. 13, p. 207. (Scientific Paper No. 272.)

such measurements centers about the determination of magnetic induction and the magnetizing force which produces this induction. The difficulties come in the determination of the magnetizing force. This force has a number of components, some of which may be calculated but others of which, due for example to the presence of joints in the magnetic circuit, may not. The presence of these joints demanded compensating adjustments for their offsetting, when the usual testing apparatus was employed, which made the test operation tedious and lengthy.

When therefore accurate magnetic test data was required the laboratory or shop had the choice of shaping their test material into a very long bar or into a closed ring, to obviate the joint difficulty, or else using a permeameter with complicated adjustments necessitating more or less skill on the part of the operator. The accurate testing of tools was usually out of the question. Most of the available permeameters which were simple in operation were notoriously inaccurate and could not be depended upon to give even comparative results save when the materials or specimens examined were practically of the same kind.

## Notes on the Use of the Pressure Gage For Pitot-Tube Measurement

BY EVALD ANDERSON

**I**N MAKING use of the Ellison or similar differential pressure gages for the measurement of small differences of pressure, as with the pitot-tube in the determination of the velocity of gases in stacks and flues, a simple modification of the ordinary connections has been found of very great advantage.

As is well known the differences of pressure that must be dealt with in gas velocity measurement are ordinarily very small. Thus, the velocity-pressure corresponding to 12 ft. per sec. at 200 deg. C. and at sea level is only about .02 inches, or two of the smallest divisions on the ordinary gage. It consequently becomes very im-

portant that the zero reading of the instrument be accurately determined, for the change in specific gravity of the liquid corresponding to the change in volume as represented by the movement of the meniscus of .01 is very slight, and the actual difference in level between any two given points on the gage is affected very little by a change of the alignment which would cause the liquid meniscus to move .01 in. On the other hand, if the actual zero reading is not known, such changes would introduce very large errors where

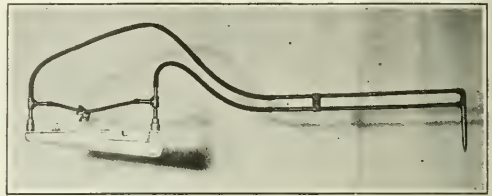


FIG. 2.—IMPROVED PITOT TUBE CONNECTIONS

the total pressure difference to be measured is of the magnitude of .02 in.

When using the standard gage, the usual operation is to fit the gage with two pipe nipples, one in each opening, and then to connect these to the pitot-tube by means of rubber tubing. Then to find the zero reading, either the rubber tubing is disconnected from the nipples, exposing both sides of the gage to the atmospheric pressure, or else the pitot-tube is withdrawn from the stack or flue and held in still air, thus approximating equal pressure on both the velocity and static openings of the tube. Both of these schemes are unsatisfactory. In the first case it is nearly impossible to change the rubber-tube connections without disturbing the alignment of the gage, and in the second case eddy currents are nearly always present, even in so-called still air, which affect the gage-reading.

To overcome these difficulties the connections and fittings shown in the sketch, Fig. 1, and the photograph, Fig. 2, were devised some years ago and have been used continuously since then. These consist simply of two pipe tees and nipples connected with a rubber tube, with a tube-clamp to close this connection. The pitot-tube is connected to the upper nipples by means of rubber tubing in the ordinary way as shown. When the zero point is to be read, the tube-clamp is opened, equalizing the pressure on both sides of the gage. Of course this can be done without removing the pitot-tube from the stack or flue where the gas velocity is being measured. When the liquid meniscus has come to rest, the zero reading is noted, the tube-clamp closed, and the gage is ready for the regular velocity reading. If the velocity of the gas in the flue or stack is high, it is necessary to close one of the connecting rubber tubes by doubling it up between the fingers while making the zero reading in order to insure correct results.

With these connections the zero point can be determined as often as desired and accurate results thereby insured. In place of the fittings shown it is of course possible to use regular metal or glass connections fitted with a valve, instead of the rubber tube together with Hoffman clamp.

Laboratories of the Western Precipitation Company,  
Los Angeles, Calif.

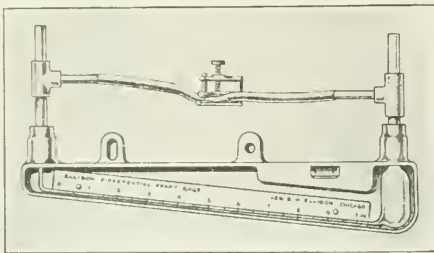


FIG. 1—SKETCH OF ELLISON GAGE AND FITTINGS

portant that the zero reading of the instrument be always known with accuracy.

This zero reading depends first on the volume of liquid in the gage, and second, on the alignment of the latter. The volume of liquid varies appreciably with the temperature of the exposed portion, while small variations in the alignment always occur from various causes. Neither of these variations introduce any appreciable error in the actual reading, provided the zero

# The Remelting of Aluminium Pig in the Electric Furnace

Electric Melting Offers Advantages in Control of Atmosphere, Temperature and Application of Heat—Description of a Plant Which Replaced Oil Furnace—Comparison of Costs

BY DWIGHT D. MILLER

Engineering Department, The Society for Electrical Development, Inc.

IN VIEW of the great success attendant upon the use of the electric furnace in the steel industry, not only for melting and refining but also for the heat-treatment of the product as well, it is only natural that there should be a demand for an electric furnace by means of which the various metallurgical processes involved in the non-ferrous field could be carried on with the same accuracy, precision and duplication of results as has characterized its use in the steel and allied ferrous fields. That there is such a demand, together with its extent and the efforts that have been and are being made to meet it, has been pointed out in a paper by the writer: "The Electric Furnace as a Medium for Heating Non-ferrous Metals," read at the annual meeting of the American Institute of Metals last September.

## ACCURACY OF CONTROL THE SALIENT FEATURE

Aside from the fact that the electric furnace has practically doubled the temperature range above zero and made it available commercially, the one great advantage secured by its use which has already established it firmly in the manufacture and conditioning of metals is summed up in the word *control*. Through no other heating medium can the same accuracy of control coupled with the nicety of adjustment and maintenance of temperature be obtained. In fact the electric furnace is pre-eminently suited for carrying out the various metallurgical processes in that by the very nature of its construction and operation it produces a non-oxidizing or reducing atmosphere.

The three vital factors involved in all metallurgical processes are atmosphere, time and temperature. Their accurate control and regulation is essential to the production of metals of the highest quality, and such control is best secured by the use of the proper type and equipment of an electric furnace.

## ELECTRICAL CONTROL

We have just seen that control of atmosphere is inherently obtained in the electric furnace. Control of temperature is of even greater importance in processing non-ferrous than ferrous metals, since the additional danger of large metal losses due to volatilization on account of superheating is always present in the case of the former. Greater accuracy of temperature control and its regulation is secured when the electric furnace is used because of the peculiar nature of electric heat and the method of its application.

Electric energy is changed into heat at 100 per cent efficiency regardless of temperature and so applied that it is concentrated at definite points or confined within a definite area in the furnace; furthermore it can be generated in any quantity regardless of temperature,

which feature is unique and renders its utilization more flexible, more efficient and the more readily controlled. On the other hand it is the lack of control of the various factors involved in the production of the heat itself as well as the nature of the appliances that renders the heat of combustion less flexible, less efficient and hinders its control.

In the one case electric energy is conducted, with but a slight loss, by means of overhead cables, which are pliable and readily portable to the exact location in which the heat is to be generated and there changed into heat without any loss by merely throwing a switch. With any given furnace, the electrical conditions, such as the line voltage, resistance of leads, electrodes, and resistor material are fixed so that the same amount of current must flow, producing the same temperature to an exact degree time and time again, and the only heat losses that must be taken care of are those due to radiation and conduction.

Moreover when it is necessary to change the temperature according to the requirements of the process it can be accurately varied in finely graded steps by voltage control—since in this case wattage is temperature.

## COMBUSTION CONTROL

In the other case, liquid or gaseous fuel must be conveyed under pressure with an appreciable expenditure of



FIG. 1.—TAPPING TYPE OF STATIONARY FURNACE

energy in rigid, stationary pipe lines which are not portable and take up valuable space. If solid fuel is used, such as coal or coke, the case is all the more exaggerated. Upon arriving at the point of ignition the fuel must be mixed with the oxygen of the air before combustion takes place, but in order to get perfect combustion, so that there shall be 100 per cent efficiency, it must be



mixed with a definite minimum quantity of the oxygen of the air, a condition most difficult to control and rarely if ever encountered in commercial practice.

In fact statistics show that the average thermal efficiency of high temperature combustion furnaces as used in non-ferrous work is in the neighborhood of 7 per cent. The control of the degree of temperature as well as its gradations are much more difficult and complicated on

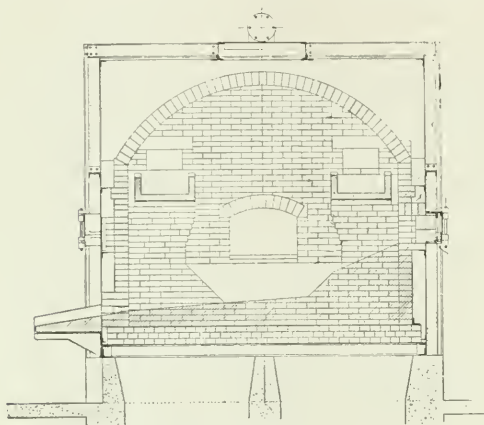


FIG. 2.—SECTIONAL ELEVATION OF FURNACE

account of the many variables involved as well as the errors of the human element always present with manual control. In addition to the heat losses due to radiation and conduction, there is the additional and greatest source of loss, i.e., heat lost by convection.

With natural draft, the draft is seldom known and not only changes from day to day but also often during each day in accordance with the variation in the direction and velocity of the wind and the humidity of the air. This condition is beyond human correction.

These advantages which are inherent in the case of electric heat more than offset its higher first cost in many instances. Many items enter into the entire cost of the finished product of which cost of heat is only one. If therefore by its use other items, such as time, labor and fire insurance, are cut in greater proportion producing a metal of higher quality—hence one commanding an increased selling price—it is evident that not only is electrically generated heat cheaper to use, but also its use is imperative in order to compete successfully with those using it in similar processes.

#### ALUMINIUM DROSS

Aluminium is not what is known as a volatile metal, it is however a very sensitive metal, absorbs impurities readily and has an affinity for oxygen, especially at high temperatures. This property has led to its use as a de-oxidizing agent, since in combining with oxygen an aluminium oxide ( $Al_2O_3$ ) known as dross is formed and can be skimmed off with the slag.

When melting aluminium pig—high-grade aluminium—if heated metal is allowed to come in contact with an oxidizing atmosphere, the loss due to dross may be as great as 5 per cent, since some of the elemental metal becomes entangled with the aluminium oxide during the

process of skimming and is lost. Hence it is most important that the melting be done in a neutral or de-oxidizing atmosphere.

#### USES OF ALUMINIUM

With the large increase in the production of aluminium by the electric process has come naturally a greater demand not only for the pure metal but also for the aluminium alloys. One of its most important uses at present is found in the manufacture of parts for the timing devices used in connection with shrapnel. Aluminium for this purpose is usually sand cast under very high pressure, thus providing a denser metal as well as a metal with increased strength. Other important uses are found in the aeroplane and automobile industries, which use large quantities of both the pure metal and the alloys, the latter combining the lightness of aluminium with the strength of the alloying material such as steel. This property is especially valuable in the manufacture of aeroplanes in which human life is dependent upon the ability of the material to withstand successfully severe and repeated sudden stresses and strains. Still other uses for the metal are found in the manufacture of aluminium foil, bottle caps, tubing for store service, rolled rods and reinforced aluminium conductors.

#### PROCESS AT THE U. S. ALUMINUM COMPANY

About one-half of the total amount of aluminium used in this country is manufactured in the plant of the United States Aluminum Co., at Massena, New York. Here the pig metal as it comes from the reduction plant

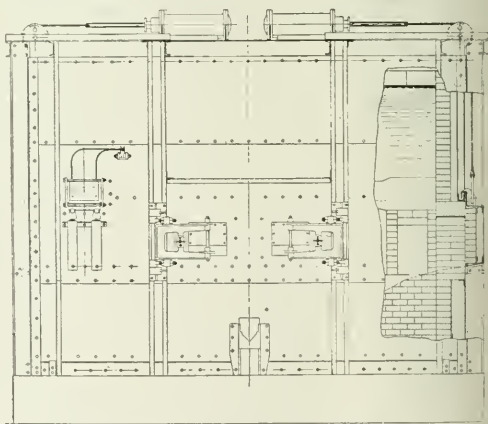


FIG. 3.—SIDE ELEVATION OF FURNACE

is remelted for the purpose of casting it into ingots or rolling billets. A number of aluminium alloys are also made and the metal heat treated in the electric furnace after having been rolled or drawn into rods or conductors. The object of this remelting is to cleanse the metal by removing in this manner the slag and scum contained from the reduction process. After the remelting there is a distinct and marked difference in its appearance, as it loses its dull finish and is much brighter.

Since a very great quantity of aluminium is handled at this plant, even the smallest saving in metal loss is important and soon manifests itself in the aggregate

savings. Hence, with the idea of experimenting with just what could be done in the way of affecting savings as well as in improving the quality of the metal, the United States Aluminum Co. installed electric furnaces both for remelting and heat treating the metal.

### THE FURNACE

The furnace selected for remelting is a stationary resistance type and has a bowl shaped hearth capable of holding three to four tons of molten metal which is discharged by tapping. It is rated at 500 kw. and designed for single-phase, 25-cycle operation.

The enclosure is rectangular and made of sheet metal suitably insulated with high-grade fire clay bricks and backed up with heat insulating material in the space between them and the metal shell. There are doors at either end of the furnace together with three rabbling doors on the side opposite the tap hole. These doors are heat insulated in the same manner as the body of the furnace. Those at the ends are opened and closed by sliding up and down vertically, being actuated by compressed air. The rabbling doors swing open on hinges. Running lengthwise with the furnace along either side are resistor troughs also rectangular in section but open at the top, made of highly refractory carbide mixed with a binder so that they can be easily molded. They are filled with resistor material consisting of finely broken carbon or graphite and supported on separate brick piers which serve to dissipate the heat generated in the troughs and diffuse it uniformly, thus avoiding hot spots in the refractory lining in the immediate vicinity of the troughs. Current enters the troughs through large copper terminals attached at the ends, making contact with the resistor material which becomes incandescent throughout in the same manner as the filament of an incandescent lamp. The heat thus generated is radiated mainly to the furnace roof and from there reflected down on the hearth and the material being treated.

Such construction provides a simple, durable and strictly commercial furnace, since all material used can be readily obtained in the open market; one in which both the atmosphere and temperature is under positive and accurate control.

When running continuously the furnace can melt one ton per hour which is tapped into graphite crucibles holding about 125 pounds. The daily output of the furnace is twenty tons.

### ELECTRICAL EQUIPMENT

Single-phase 25-cycle current enters the building at 2200 volts and is there stepped down to 500 volts, at which pressure it enters the primary side of a special regulating transformer always provided with the furnace. This transformer consists of 9 selective, oil-break, hand-operated switches by means of which the temperature is regulated and held constant by voltage control. The actual voltage required varies with the resistance of the resistor material in the troughs and the required degree of temperature of the material being processed. That actually used in the furnace ranges from 500 down to 240 volts.

In addition to the usual operating main line switch, there is an indicating and integrating wattmeter, also

a pyrometer mounted on the switchboard. This pyrometer is connected to a thermocouple which protrudes through the roof well into the furnace. Hence an accurate record is had at all times of the amount of power being consumed, the total consumed each day as well as the degree of temperature attained.

### OPERATION

Upon closing the main line switch, current at full operating pressure flows through the resistor material. Due to the negative temperature coefficient of this material (broken carbon or graphite), it is a poor con-

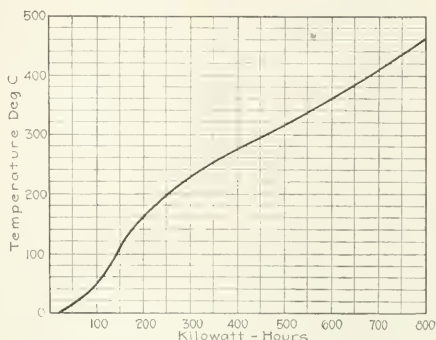


FIG. 4.—POWER CONSUMPTION CURVE

ductor when cold and offers resistance to the passage of the current at the start. This resistance transforms the electrical energy into heat, and the resistor material begins to heat up. The hotter it gets the better electrical conductor it becomes, and more current flows, soon raising the material to an incandescent heat. Any tendency to overpower the furnace is immediately indicated by the wattmeter on the board and quickly corrected by connecting one of the selective oil-break switches which lowers the voltage and checks the power input. There is a slight voltage fluctuation during this heating-up period, but as soon as the troughs have attained the desired temperature the resistance of the resistor material remains practically constant and the current flow automatically adjusts itself to a steady inrush. The special regulating transformer is also used to secure accurate adjustments in the degree of temperature in accordance with the requirements of the material under treatment.

### CHARACTERISTICS OF THE FURNACE

Curves are here given showing the power input necessary to bring the furnace up to operating temperature, also the rate of cooling. These curves apply to a 50 kw. annealing furnace in use at the plant, but of the same electrical design and construction as the melting furnace. It will readily be seen from the cooling curve that having once attained temperature, the furnace retains the heat to a remarkable degree—in other words is sluggish. This characteristic is used to great advantage in keeping down the amount of power required to carry on the process, especially under continuous operating conditions as is here the case. For instance, with the furnace full of molten metal, the pyrometer indicating a

temperature of 1050 deg. C. (1922 deg. F.), which means that the bath was about 850 deg. C. (1562 deg. F.), on account of the temperature head between roof and bath, this temperature was maintained constant with the regulating transformer on only the fourth step and an input of 265 kw., and this under the condition of continuous addition of cold metal as the hot metal was tapped from time to time. In another plant where the

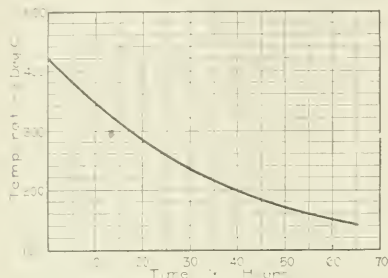


FIG. 5.—RATE OF COOLING

furnace is operated intermittently they make the last heat of the day on practically the stored energy of the furnace.

After the metal is tapped it is cast into ingots or rolling billets and either sold to the trade or further worked in the plant.

The castings are subjected to a pressure of 25,000 pounds per square inch by means of molds operated by a horizontal hydraulic ram. This ram is situated in the center of the press with the molds on either end of the shaft. As the pressure is exerted on one set of molds the others are opened and the castings removed.

Several kinds of alloys, some containing zinc, are also made in the plant, and it is in this process that the greatest savings are made by the use of the electric furnace. Metal losses due to an oxidizing atmosphere as well as those due to volatilization and the carrying off of fine particles by convection currents, which in some cases is the greatest source of loss, are entirely eliminated. In fact, it is the possibility of the elimination of just such losses as these that is rapidly establishing the electric furnace in the same position in the non-ferrous field as it now occupies in the ferrous industries.

#### ANNEALING

In order to relieve the metal of the stresses and strains produced in working it, also to further develop the inherent physical characteristics of the alloys, some of the product is annealed in an electric furnace of the same general type as that used for melting.

It is now a well recognized and established fact that heat treatment contributes more to the superior physical qualities contained in various alloys than does the addition of the alloying elements.

The annealing furnace is known as the car type and while originally rated at 50 kw. it is often worked with a power input of 100 kw. The platform of the car is made of fire-clay brick, on which the material to be treated is loaded in such a manner as to allow of free circulation of the radiated heat around all parts of the charge and its even penetration.

The loaded car is run in and out of the furnace, which has only one door, on tracks, being actuated by motor-driven gearing located beneath the floor.

The capacity per hour of metal treated as well as the time it is left in the furnace together with the degree of temperature used will depend upon the material being processed. The temperature generally used however varies from 350 to 500 deg. C. (662 to 932 deg. F.) and the time from two to five hours.

The furnace is also equipped with a special regulating transformer, switches, wattmeter and pyrometer so that the same degree of accuracy of control and recording of conditions at all times is had as is the case with the remelting furnace.

A curve is here given showing the time required to anneal different amounts of aluminium with a steady input of 50 kw. per hour starting with a hot furnace 425 deg. C. (797 deg. F.) which is held constant.

#### RESULTS OBTAINED

The advantages which are secured by the use of the electric furnace are summed up by Mr. H. M. Hall, Superintendent, as follows:

- 1.—The electric furnace replaced an oil furnace burning crude petroleum oil which produced large losses, particularly in the case of alloys containing volatile constituents such as zinc.
- 2.—The electric furnace gives much more uniform mixtures with much less losses.
- 3.—The cost of electric power compares very favorably with the increased cost of fuel oil which was becoming prohibitive.
- 4.—Savings are effected by the use of the electric furnace in that the metal losses are less and the thermal efficiency greatly increased.
- 5.—Where coal fired furnaces are used, there is a saving of one or two men in favor of the electric furnace.

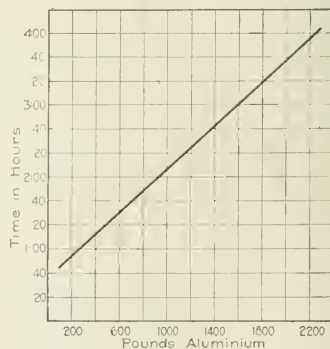


FIG. 6.—ANNEALING TIME

6.—There is also a saving in space required per pound or ton of metal melted in favor of the electric over the coal fired furnace.

7.—The electric furnace is a much cleaner, cooler furnace for the men to work around than is the case with an externally fired fuel furnace.

It is evident that while improved quality of product was the end sought, economy of operation resulted from the use of electricity as the heating medium.



# Synthetic Phenol\*

Description of Old Process Used Prior to Introduction of Dennis-Bull Process—Great Economies Effected in Use of Sulphuric Acid and Caustic Soda as Well as in Transportation of Raw Materials

By A. G. PETERKIN

IT IS difficult to estimate the quantity of any of the products from coal tar which are available, because on the one hand the production of tar is changing from day to day, due to the continued increase in the number of coke ovens, and on the other hand its consumption for fuel purposes is affected by greater or less difficulty in obtaining supplies of coal. It is safe to say, however, that it would not be practical or even possible to-day to make more than five to six million pounds of phenol per year from this source.

The United States used before the war some 5,000,000 lb. of phenol per year, the consumption being divided between pharmaceuticals, resins of the Bakelite type, dyestuff intermediates, and the explosive, picric acid. At the beginning of the war the demand immediately increased, due to the increased manufacture of picric acid. The French Government particularly became a large customer of manufacturing concerns in this country, both for phenol and picric acid. The production just before the entrance of this country into the war had jumped to something like 72,000,000 lb. of phenol per year.

It is likely that 1919 will see a very great increase in the production of phenol in this country. Coal tar as a direct source of phenol is therefore a negligible factor in view of the present demand.

Whatever the merits of picric acid as an explosive, a real objection to its manufacture in such times as these lies in the relatively enormous amount of raw materials involved, and the necessity for the correspondingly great consumption of our valuable transportation facilities. For example, to make 100,000,000 lb. of synthetic phenol requires in round numbers:

|                                   | Pounds      |
|-----------------------------------|-------------|
| Benzol .....                      | 115,000,000 |
| Fuming Sulphuric Acid (9½%) ..... | 280,000,000 |
| Caustic Soda .....                | 180,000,000 |
| Lime .....                        | 42,000,000  |
| Limestone .....                   | 190,000,000 |
| Coke .....                        | 35,000,000  |
| Niter Cake .....                  | 42,000,000  |
| Total .....                       | 884,000,000 |

or nearly nine times that of the finished product, using the generally adopted process and working with fair economy. To say that it is an extravagant process is to put it mildly, but it has maintained itself with considerable obstinacy in the face of many attempts to improve and shorten it.

## OUTLINE OF OLD PROCESS

The illustration, Chart I, shows the old process diagrammatically. It has been described many times, and a bare outline will suffice now. Benzol is sulphonated at temperatures varying from 50 to 70 deg. C. The

strongest acid that may be used with economical results in the writer's opinion is fuming sulphuric acid containing 9½ per cent of free SO<sub>3</sub>, the limitation being enforced by the necessity of avoiding the formation of diphenyl-sulphone. Since the composition of the spent acid from the sulphonation is a constant, the amount of sulphonic acid necessary for the completion of the reaction is increased very largely as the concentration of the initial acid is decreased. It has, therefore, not been considered economical to use acid weaker than one containing 98 per cent H<sub>2</sub>SO<sub>4</sub>. The figures given above are for the higher concentration. The result of the sulphonation is a solution of sulphonic acid, sulphuric acid and water. The sulphuric acid and water together make a spent acid of approximately 80 per cent H<sub>2</sub>SO<sub>4</sub> and 20 per cent H<sub>2</sub>O. The solution then contains in round numbers 60 per cent sulphonic acid and 40 per cent spent sulphuric acid. The sulphonic acid is required in the form of sodium salt.

The procedure in all plants is essentially the same, although many minor variations have been adopted. Slaked lime is placed in the agitators and the mixture of sulphonic and sulphuric acid slowly added during agitation. The sodium salt may be formed by addition of sodium sulphite obtained from the fusions later in the

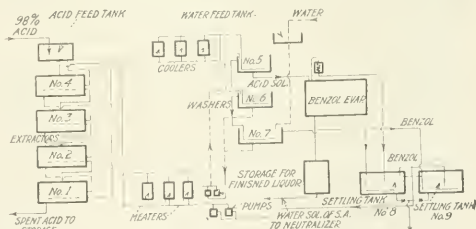


CHART I.—OLD SYNTHETIC PHENOL PROCESS

process. When this procedure is adopted, the mixture in the agitators consists of a water solution of sodium benzene sulphonate and a mixture of solid calcium sulphite and calcium sulphate. The whole is heated to 115 deg. C. in order to obtain the sulphate in proper crystalline form for filtering, and is passed through the filter presses. The resulting solution of sodium benzene sulphonate contains approximately 12 per cent of the salt and small quantities of calcium sulphate, due to the slight solubility of this material.

It is important to remove all calcium salts, both for the sake of the tubes in the evaporators and because of the havoc they cause in the fusion operation. This is accomplished by the addition of the necessary small amount of sodium carbonates and refiltration. Some

\*A paper read at the meeting of the Amer. Inst. of Chem. Eng., Gorham, N. H., June 19-22, 1918.

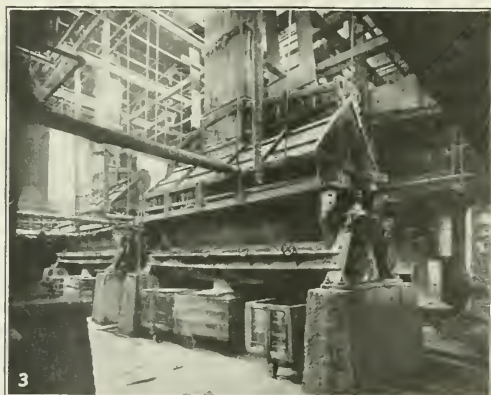
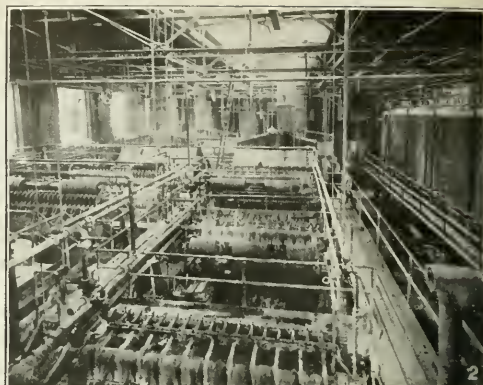
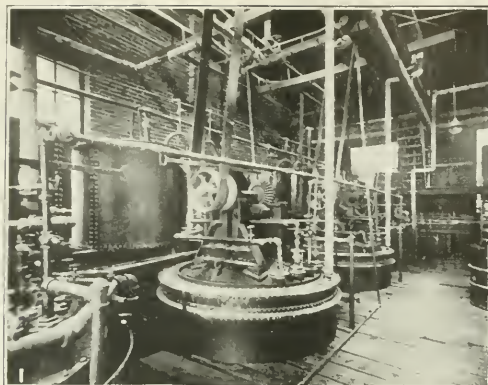


FIG. 1.—SULPHONATORS, TOP VIEW  
FIG. 3.—DRUM DRYERS

FIG. 2.—FILTER PRESSES  
FIG. 4.—GENERAL ARRANGEMENT SPENT ACID PLANT

factories make the soda salt in two steps, adding sodium carbonate to the filtered solution of calcium benzene sulphonate; others add only the amount of lime necessary to react with the sulphuric acid, in making the soda salt in one step, which makes the use of the by-product sulphite difficult, due to the liberation of  $\text{SO}_2$ . The 10 per cent solution is evaporated down to the saturation point, and the salt obtained from the syrup by means of drum dryers. The salt, preferably retaining about 10 per cent of water, is fed into melted caustic soda in the fusion kettles, there being about one molecule of soda in excess. The temperature during the fusion is maintained between 320 and 350 deg., the salt being fed in slowly during the operation.

The critical temperature of the reaction appears to be 320 deg. C. As the result of the fusion, a light brown liquid mass with the appearance of melted chocolate is obtained, which is poured hot into such an amount of water as will dissolve the phenolate and leave the sodium sulphite in solid form. This is done in vessels marked "dissolvers" which are provided with stirrers. Only about 10 per cent of the sulphite formed remains in the solution and this amount can undoubtedly be decreased. The phenolate liquor is filtered from the sulphite on open sand filters. The sulphite is agitated with water, separated by means of filter presses, washed

free of phenol and marketed as an impure sodium sulphite. A typical analysis of this material is:

|                                          | Per Cent |
|------------------------------------------|----------|
| Moisture .....                           | 24.20    |
| $\text{Na}_2\text{SO}_3$ .....           | 7.12     |
| $\text{Na}_2\text{SO}_4$ .....           | 62.30    |
| Insol. in hot $\text{H}_2\text{O}$ ..... | 0.46     |
| $\text{CaH}_2\text{ONa}$ .....           | 0.60     |

The wash water is used in the dissolvers so that its sulphite is deposited again on the filter beds.

The phenolate liquor is carefully diluted to a gravity corresponding to a phenol content of about 16 per cent. This diluted solution is placed in a series of tanks, and 30 per cent carbon dioxide gas generated from a mixture of coke and limestone passed through it. These so-called "blowers" are arranged so that the gas may pass from one to another in any direction desired. The strong gas goes first through the almost neutralized phenolate and leaves from a strongly alkaline solution, thus avoiding any possibility of loss due to the vapor pressure of phenol at the temperature of the spent gases involved which is about 50 deg.

It is impossible to entirely neutralize the phenolate solution by means of carbon dioxide in one operation, at any rate, unless such a large excess of  $\text{CO}_2$  is introduced as to transform all the carbonate to bicarbonate, which is undesirable. When the passage of the gas is



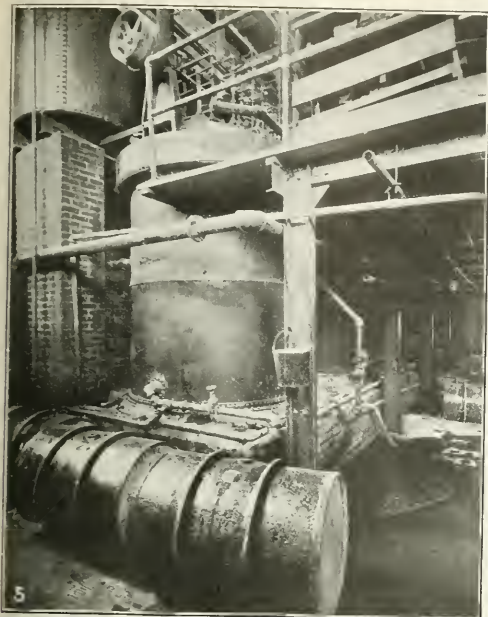


FIG. 5.—SULPHONATORS, SIDE VIEW  
FIG. 7.—EVAPORATORS AND DISSOLVERS

FIG. 6.—AGITATORS  
FIG. 8.—COOLERS

discontinued the phenol layer contains in solution about 10 per cent phenol as sodium phenolate, while the carbonate layer is free from phenolate but contains approximately 2 per cent of phenol. The carbonate is completely freed from phenol by means of a steam dis-

tillation; a 4 per cent solution of phenol is obtained in this way. The crude phenol containing 10 per cent of phenolate may be completely acidified with  $\text{CO}_2$  by replacing the carbonate solution with water. Niter cake, however, used as an acidifying agent has the ad-



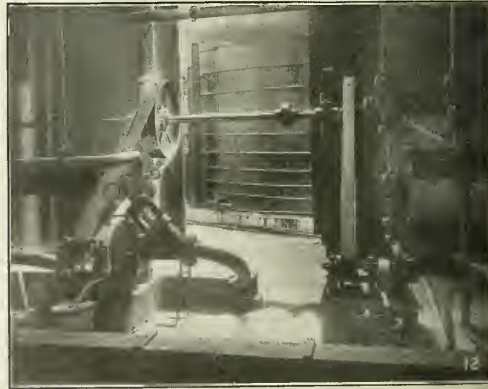
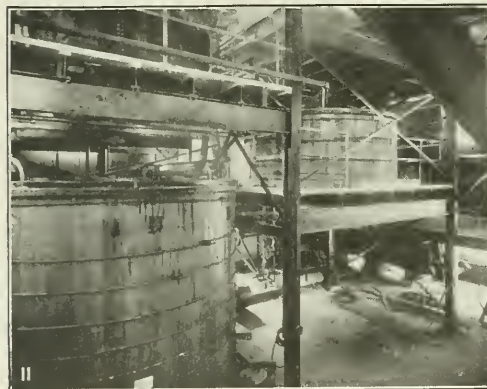


FIG. 9.—RECORDING GAGE, AUTOMATIC TEMPERATURE CONTROL  
FIG. 11.—FINAL WASH TANK AND RECEIVER

FIG. 10.—WASHERS  
FIG. 12.—TWO SMALL PUMPS ONLY REQUIRED IN THE PROCESS

vantage of simultaneously removing a large percentage of the water present. The dehydration reduces the water content of the crude phenol from 30 to less than 14 per cent and relieves the refining stills of a great burden. The crude acid is placed in a simple still from which is obtained a first fraction of water and phenol, a middle fraction of pure phenol and a residue of the more complex phenolic bodies formed in the fusion. The synthetic phenol produced is exceedingly pure; it is comparatively easy to obtain material melting at 40 deg. C. Redistillation gives a product melting at 40.6 deg. The true melting point of pure phenol is in our opinion 40.8 deg.

#### ECONOMIES TO BE EFFECTED IN THE PROCESS

The great economies possible in the process are obviously to be made in the cutting down of the 100 per cent excess of sulphuric acid, the reclaiming of the caustic soda and the marketing of the sodium sulphite in a useful and valuable form. The maximum yield which has been claimed for the process is about 80 per cent. Our work has shown that the fusion operation alone will not give more than 90 to 92 per cent of the theoretical yield; in practice it is difficult to maintain this high standard. Under present conditions, the average American practice probably results in a total

overall yield of between 60 to 75 per cent. As chemical processes go, the process requires an inordinate amount of labor and the repeated handling of the material gives ample opportunities for mechanical losses, particularly in view of the present restlessness of workmen.

Two methods have been suggested to reduce or conserve the excess of sulphuric acid used. Daniel Tyrer of England (U. S. Patent, No. 1,210,725) passes benzol vapor through sulphuric acid of as low concentration as 90 per cent  $H_2SO_4$  at temperatures varying between 100 and 185 deg. C. That part of the benzol vapor not reacted upon carries with it to a condenser the water of reaction, and so gives a constant concentration to the sulphuric acid, keeping it active. Tyrer claims in this way to get about 80 per cent of the amount of sulphuric acid theoretically obtainable from the sulphuric used. This method has not yet been tried on a large scale in this country.

#### METHOD OF DENNIS AND BULL

The second method is that of Dennis and Bull, the practical application of which has been worked out by the Barrett Company. Some two years ago, Professor L. M. Dennis<sup>1</sup> at Cornell University discovered that al-

<sup>1</sup>U. S. Patents, Nos. 1,212,612, 1,211,923, 1,227,894, 1,228,411 and 1,229,593.

though the solubility of pure sulphonic acid in benzol was negligible, benzol would take up from the mixture of sulphuric and sulphonic acids between 2 and 3 per cent of its own volume of the sulphonic acid. In working out this idea it occurred to Mr. Hans Bull of that company that the sulphonation could be made simultaneously with the extraction. These ideas have been utilized in the evolution of an extremely simple process which not only saves 90 per cent of the excess sulphuric acid as a spent acid containing 70 to 77 per cent  $\text{H}_2\text{SO}_4$ , but eliminates a good percentage of labor, all the lime, and substantially reduces the deplorable cost of repairs, due to the many moving parts of the old installation.

The process will be easily understood from Chart II. The vessels 1, 2, 3 and 4, so-called "extractors," contain at rest a layer of a solution of sulphonic and sulphuric acids of varying proportions. The benzol passes continually upward through this series of extractors, the vessels being under a pressure equivalent to the head of benzol. The distribution of the liquid in fine bubbles is effected by means of perforated branch pipes. After the passage of the benzol for a certain length of time, the solution in No. 1 is free from sulphonic acid and consists of 77 per cent  $\text{H}_2\text{SO}_4$ . When this has been accomplished, the so-called "spent acid" is withdrawn. The solution in No. 2, which probably contains 10 per cent of sulphonic acid is dropped into No. 1. The solution in No. 3, which contains probably 25 per cent sulphonic acid is dropped into No. 2, and the solution in No. 4, which contains probably 40 per cent sulphonic acid is dropped into No. 3.

Into No. 4 is then slowly introduced a charge of 98 per cent sulphuric acid. The flow of benzol is not interrupted at any time. Sulphonation takes place almost immediately and the volume of the benzol flowing through, approximately 200 gallons per minute, is so great as to effect almost instantaneous removal of the heat of reaction. The benzol is maintained throughout at a temperature of 60 deg. C. by heaters at the bottom of the system and coolers at the top.

After passing through the coolers, the benzol, which will contain approximately 2 per cent sulphonic acid, passes successively through the washers, 5, 6 and 7, containing water. The benzol falls from one vessel to another by gravity, there being no pressure on this part of the system. The sulphonic acid remains in the water and the benzol leaves the last washer entirely relieved of its burden. It is passed to large settling tanks where the rate of flow is slowed down to such an extent as to allow the sulphonic acid solution, carried in suspension, to settle, and from these tanks flows to the pump and is forced through the heaters to the extracting system once more.

When such an amount of sulphonic acid has been deposited in Washer No. 5 as to bring it to the strength desired, it is removed to an evaporator and the solution from Washer No. 6 pumped to No. 5, and that from No. 7 to No. 6. Fresh water is put into No. 7. A water solution of sulphonic acid can be obtained containing 60 per cent or even more sulphuric acid and containing also about 2 volumes per cent of benzol in solution. The benzol is removed by evaporating a small percentage of the water. The solution of sulphonic acid is then neutralized, either by the carbonate solution

from the phenol blowers or with the solid sulphite of soda. The sodium benzene sulphonate obtained contains some 5 or 6 per cent of sodium sulphate, due to

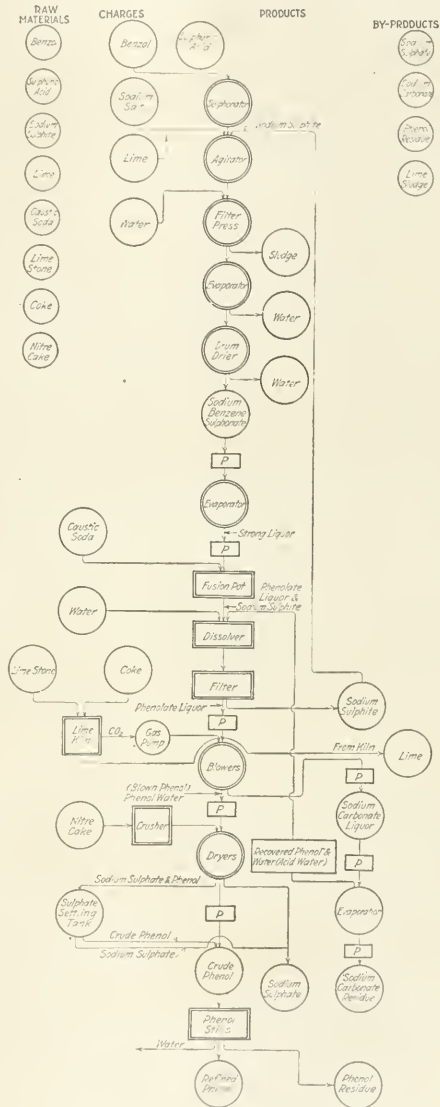


CHART II.—FLOW SHEET, DENNIS BULL PROCESS

the solubility of sulphuric acid in the benzol solution of sulphonic acid (one part sulphuric to twenty parts sulphonic).

#### ADVANTAGES OF THE PROCESS

The advantages of the process are obvious. The initial cost of the plant is about 50 per cent of that of the old style plant, which it displaces. Moreover, it runs practically without attention and requires from one-third to one-fourth the number of laborers. Tak-

<sup>1</sup>U. S. Patents, Nos. 1,247,499 and 1,260,852.

ing for granted complete extraction of the sulphonic acid, which proves quite possible, and a removal of the benzol from the water solution of sulphonic acid, the losses possible are confined to mechanical causes, that is, either leaks or evaporation. The yield under the old process, from benzol to sodium benzene sulphonate, is about 90 per cent. The new process makes easily possible a yield of 98 per cent, leaving the mechanical losses out of consideration. The formation of disulphonic acid and of sulphone is negligible. The operations: (1) discontinuous sulphonation, (2) liming, (3) filtering, and (4) evaporating, involving complex machinery and many moving parts, have all been displaced with the one simple and continuous operation, extraction and sulphonation going on simultaneously, the only moving parts being two small pumps. The enormous simplification of the process achieved will be made more evident by photographs shown in Figs. 1 to 12 than by any description. The spent acid is concentrated to 93 per cent and used repeatedly.

Another improvement in the process very generally adopted has been the so-called "liquid fusion," by means of which the drum dryer with its dust and spatter has been eliminated. Liquid fusion consists in the introduction of a saturated solution of sodium benzene sulphonate directly into liquid caustic soda at a point above the reaction temperature. The reaction, when the temperature is properly controlled, goes even more smoothly than with the solid, since there is no tendency to dust and float, and the rapid evolution of the steam gives better agitation. The fusion is a great source of loss in yield. Well conducted fusions, where the temperature has been kept down and which for that reason show no evidence of oxidation, give between 86 and 90 per cent yield. Our experience shows that using the liquid fusion method, a high yield is more easily obtained than with the dry salt.

#### ECONOMY OF CAUSTIC SODA

So much for innovation. Another important economy to be achieved in this process, and one even more important than that of sulphuric acid, is that of caustic soda. Neutralizing the phenolate with sulphuric acid, as is often done, is a gross and inexcusable waste. Providing that the lime can be utilized, the difference in cost between the neutralization with  $\text{CO}_2$ , as generated from limestone, and with sulphuric acid is immeasurably in favor of the former and the operation is exceedingly simple, once the necessity for clear solutions is understood and the fact of the solubility of phenolate in phenol recognized. If any salts are precipitated by the carbonation of the phenolate, an emulsion is obtained from which the phenol will settle only with great difficulty. The avoidance of this emulsifying is merely a question of dilution, however, and no real obstacle is involved. The soda, not only of the phenolate, but the excess soda, is gotten in the form of a weak solution of sodium carbonate, which can be readily causticized and made available for the fusion operation.

The fusion reaction is:



If half of the sulphite is used for the formation of the soda salt, only one molecule of soda is consumed and this goes out of the plant in the form of sodium sulphite, a useful and marketable product. Since in the

Barrett process  $\text{SO}_2$  is evolved from the neutralization of the sulphonic acid, it is possible also to produce bisulphite of soda.

The large amount of limestone needed is not a relatively important objection from the point of view of cost, but it presents a transportation problem of considerable magnitude. The disposition of the calcium carbonate sludge from the causticization may, and in our case does, involve considerable expense. From the point of view of transportation alone, the calcination of the carbonate sludges, in rotary kilns, as a source of  $\text{CO}_2$  and of lime is justified. This has been successfully tried in connection with other operations and has been found economical in districts somewhat remote from the limestone fields.

The various economies indicated will result in a startling decrease of raw materials:

|                      | Per Cent |
|----------------------|----------|
| Sulphuric acid ..... | 40,      |
| Caustic soda .....   | 60,      |
| Lime .....           | 90,      |
| Limestone .....      | 100,     |

and a corresponding decrease of tonnage to be transported from a total of 884,000,000 to 397,214,400, per million pounds of phenol, or about 50 per cent.

#### Paint Thinning Calculations

In producing a standard weight per gallon of paint or varnish mixture, the cross subtraction scheme is valuable, because of being easily remembered as well as giving accurate ratios readily. For example, if an eight pound to the gallon paint is desired, the materials to be mixed being 20-lb.-gal. paste and 7.5-lb.-gal. linseed oil, then:

$$\begin{array}{l} \text{(Paste)} \quad 20 \times 8 \leq \frac{1}{2} \text{ gal.} \\ \text{(Oil)} \quad 7\frac{1}{2} \leq 12 \text{ gal.} \end{array}$$

The gallon weights, 20 for paste,  $7\frac{1}{2}$  for oil and 8 for the desired mixture are set down as in the above and the differences taken as the equations indicate, no attention being paid to positive or negative signs. The differences  $\frac{1}{2}$  and 12 are the ratio numbers. Thus, to every half gallon of paste, twelve gallons of oil must be added, in order to obtain an 8-lb.-gal. paint. Now if a ton of 8-lb.-gal. paint is desired, 250 gallons must be made, the ratio  $\frac{1}{2}$  to 12 or 1 to 24 requiring for this mixture 10 gallons of 20-lb. paste and 240 gallons of  $7\frac{1}{2}$ -lb. linseed oil. If it is desired to thin this paint to 7 lb. 15 oz. with spirits of turpentine (7.2-lb.-gal.) or naphtha (6-lb.-gal.) each calculation is as follows:

$$\begin{array}{l} \text{(Paint)} \quad 8 \times 7.94 \leq 0.74 \text{ gal.} \\ \text{(Turpentine)} \quad 7.2 \leq 0.06 \text{ gal.} \\ \text{(Paint)} \quad 8 \times 7.94 \leq 1.94 \text{ gal.} \\ \text{(Naphtha)} \quad 6 \leq 0.06 \text{ gal.} \end{array}$$

So that the gallon ratio of paint to thinner would be 74:6 and 194:6 respectively. As two hundred and fifty gallons of 8-lb.-gal. paint are to be thinned; the gallons of thinner to be added would be:

$$\text{Turpentine, } \frac{250}{74} \times 6 = 20.27 \text{ gal.}$$

$$\text{Naphtha, } \frac{250}{192} \times 6 = 7.8 \text{ gal.}$$

As the pigment concentration is a function of the gallon weight, it is considered good practice to regulate paint mixture by gravity as well as by viscosity tests.



## Synopsis of Recent Chemical and Metallurgical Literature

**Tin-Wolfram Concentrators.**—*Chemical Engineering and Mining Review* for December, 1917, contains an article by JOSEPH MILLER on the concentrator at Storey's Creek, Tasmania, and the issue for June 5, 1918, contains similar information on Butler's Tin Mine, Torrington, N. S. W.

The Storey's Creek ore contains massive, easily detached, wolframite and cassiterite, amenable to hand picking. Their mill, of a capacity of 30 tons per eight hours, is shown in the diagram (Fig. 1) which requires no elaboration, except as to the table section. The concentrates from the three coarse tables are treated in a hydraulic cleaner, which eliminates the fine pyrite, and the overflow is retreated on the slime table. The middlings are re-treated, being fed by water jet when poor ore is being sent to the mill. Overall recoveries are said to be above 85 per cent. The concentrates are treated in two Thompson-Davies electro-magnetic separators. Classification, like drying, is absolutely necessary as a preliminary to this step. The screen classifier

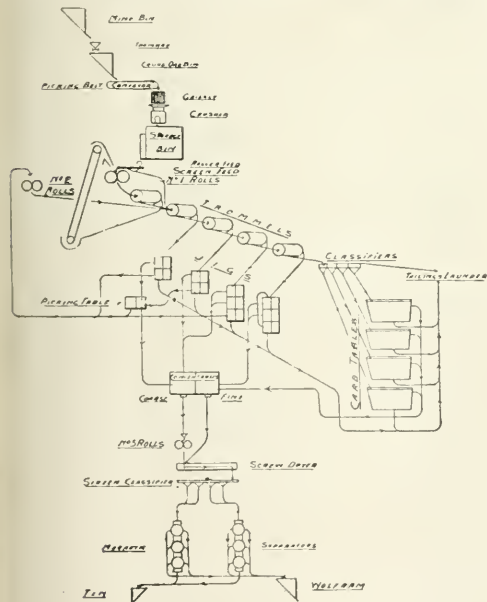


FIG. 1.

consists of a series of sieves, the coarsest having six holes per inch; while oversize is returned to the rolls. Each magnetic machine has three poles and three discs and a 15-in. feed belt. The feed is delivered by means of glass funnels, discharging on an inclined smooth convex plate which spreads the material in a thin even layer on the belt, of a thickness about equal to the size of the particles being fed.

At Butler's Tin Mine, as shown in the flow sheet in Fig. 2, three methods of concentration are in use. Wet

concentration practiced in the primary plant recovers 80 per cent of the tin contained in the ore, and about 67 per cent of the tungsten and lead. The concentrate analyzes to Sn 53, WO<sub>3</sub> 12, and Pb 5 per cent, which is too high in lead for disposal. The latter is almost

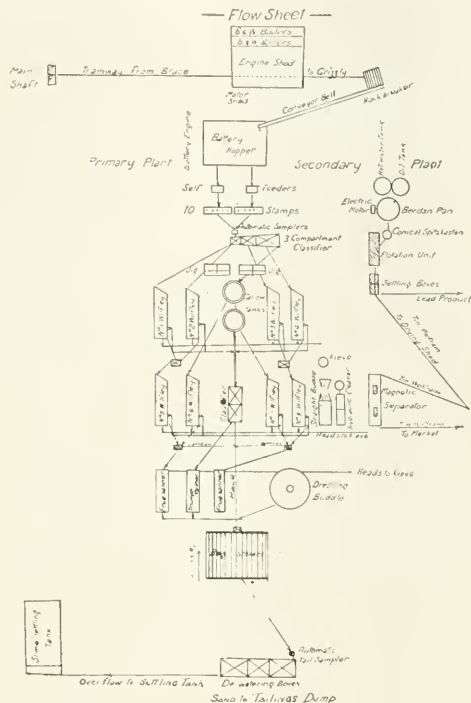


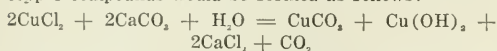
FIG. 2.

completely recovered in a M. S. flotation unit, and the tin and tungsten separated magnetically after drying. The overall recovery is considered good in view of the excessive amount of slimes produced.

**Influences of Positive and Negative Ions on Concrete**—Mr. J. C. Witt in the *Philippine Journal of Science*, 1918, 15A., p. 28-29, gives an account of the influence of several salts on the setting of cement. Comparative conditions were not arranged so that general deductions can not be drawn. Experiments were made with four cements and eleven salts under similar conditions—chlorides (Na, Zn, Cu), nitrates (Na, K, NH<sub>4</sub>), sulphates (Na, Zn, Cu) and bicarbonates (Na, K). The effect was generally to lower the tensile strength, and any increase, which was usually associated with sulphate, was very small. The cement with the highest content of calcium seemed to be affected the most. The sulphates and chlorides of zinc and copper caused a retardation in the initial set, which increased with the concentration. The other salts caused a varying retardation which reached a maximum and then diminished. The positive ion seems to have the greater influence, which would naturally be expected, inasmuch as it would effect the ionized calcium.

## Recent Chemical and Metallurgical Patents

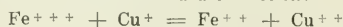
**Leaching Process.**—EVALD ANDERSON, of Los Angeles, patents a process of leaching copper ores containing carbonates by means of an electrolyte containing ferrous salts, which effectually prevent the precipitation of insoluble copper compounds. As a specific instance he agitates one ton of 0.5 per cent copper ore containing some limestone with two tons of leach containing 1 per cent Cu as  $\text{CuCl}$ , 0.5 per cent Fe as  $\text{FeCl}$ , 5 per cent NaCl, and 5 per cent  $\text{CaCl}_2$ . The  $\text{CuCl}$  takes the copper into solution as  $\text{CuCl}$ . Ordinarily, insoluble copper compounds would be formed as follows:



In the presence of ferrous chloride, however, these insolubles are partly dissolved and partly reduced, thus:

$$3\text{CuCO}_3 + 3\text{Cu(OH)}_2 + 4\text{FeCl}_2 + 3\text{H}_2\text{O} = 4\text{Fe(OH)}_3 + 2\text{CuCl}_2 + 4\text{CuCl} + 3\text{CO}_2$$

In the last reaction, ferrous iron is oxidized by cupric copper, the reverse of the usual reaction:

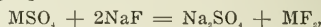


In this case, however, the concentration of ferric ions is reduced to such an extent, due to the insolubility of the hydrate, that the usual reaction is reversed.

After agitation the leach solution is withdrawn and the ore washed, the combined leach and wash water

passing through an electrolytic chlorine cell, when the ferrous chloride is oxidized to ferric chloride, and the latter oxidizes cuprous chloride to cupric chloride. Sufficient NaCl is added to bring the sum of NaCl and  $\text{CaCl}_2$  up to 10 per cent, when the original leach is reconstituted. The total iron in the solution is kept balanced by selection or concentration of the ore, or by oxidizing and precipitating an excess with carbonates present in the ore. A deficiency would be made up by adding suitable salts. Precipitation of dissolved copper may be effected in the electrolytic tank, when the deficit of iron would be made up as above. (1,263,727; assigned to International Precipitation Co., Apr. 23, 1918.)

**Cerium Fluorides.**—In the method of preparing non-hygroscopic cerium and other rare earth fluorides from the sulphuric acid extraction of monazite sands in connection with the manufacture of thorium compounds for Welsbach mantles, MR. DEAN BURNS of Lakewood, Ohio (assignee, National Carbon Co., Cleveland, Ohio), has patented the process of washing the occluded sulphates from the fluoride precipitate with a solution of sodium fluoride in accordance with the following equation:



where M represents the occluded rare earth metal. This reaction takes place slowly at ordinary temperatures, but upon calcination runs to completion. This treatment produces an almost 100 per cent pure precipitate, whereas without the washing 20 per cent of occluded sulphates would be present, making the product very hygroscopic and unfit for use in the manufacture of arc lamp electrodes. (1,272,375, July 16, 1918.)

**Pyridine from Ammonium Sulphate Mother Liquor.**—Messrs. FRANK E. DODGE of New York and FREDERICK H. RHODES of Philadelphia patent the process of recovering the pyridine bases from the bath liquor of the direct or semi-direct ammonium sulphate process by the neutralization of the bath liquor with ammonia, etc., and consequent decomposition of the pyridine sulphates, and the subsequent recovery of the freed water-insoluble pyridine bases from such neutralized baths by agitating the solution with a pyridine oil solvent, which is readily separated and the pure pyridine bases distilled therefrom. The purified alkaline ammonium sulphate is returned to the extraction bath and may be used to wash the crystallized salts en route. (1,274,998-1,275,000; Aug. 6, 1918.)

**Pyroxyline Composition of Exceptional Durability.**—Camphor-collodion compounds of the ordinary type are usually more or less brittle. Mr. PEPPINO MAJORANA of Louisville, Kentucky, finds that alcohol used in compounding the ingredients gives specially desirable products. He patents a composition within the limits:

|                    | Per Cent  |
|--------------------|-----------|
| Clear collodion    | 75. — 85. |
| Spirits of camphor | 5.5 — 7.5 |
| Gum camphor        | 8 — 10.5  |
| Dye                | 2. — 3.   |

In the manufacture of phonographic ribbons having sound wave lines pressed into both sides, it is claimed that there is no liability of the material to tear or break, even at these areas of minimum thickness. (1,275,063; Aug. 6, 1918.)

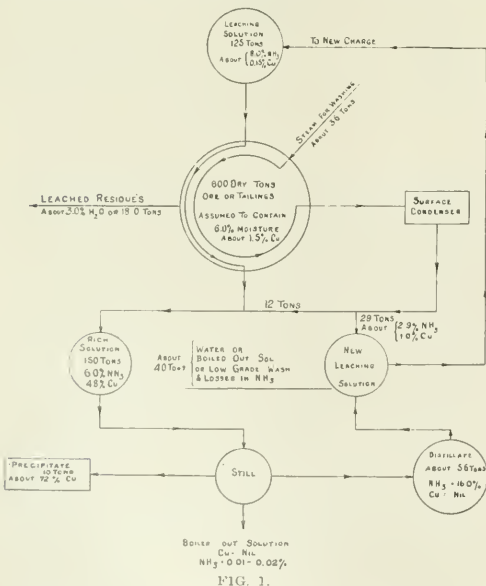


FIG. 1.

equalling two tons as at the first, but carrying 1.24 per cent Cu, partly cuprous and partly cupric. Of this, 0.386 tons are passed over scrap iron to recover cement copper, and an equivalent amount of iron is dissolved as  $\text{FeCl}_2$ . The barren solution is reunited to the pregnant leach, 8.5 pounds of chlorine added by

**Starting Sheet Suspension.**—HENRY S. MONTGOMERY and HENRY A. TOBELMANN, of Ajo, Ariz., have found that an electrolytic starting sheet, if hung between the ends of a loop, riveted thereto, will not build up at the edge between the loop ends, but on the contrary, the sheet is dissolved at such a rate that it falls from its support into the tank before any considerable metal has been deposited. In order that the loops and sheet may remain connected it has been found that the connection

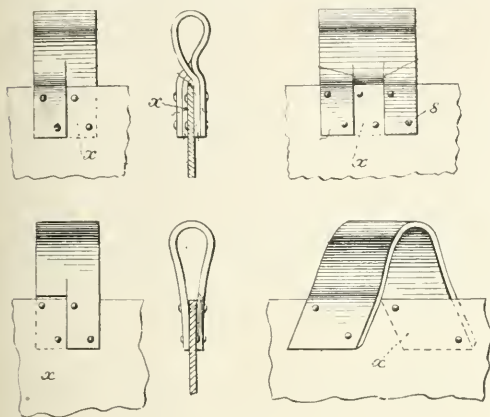


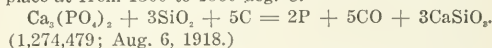
FIG. 3

should be made in such a way that there shall be no metal of the sheet between the layers formed by the loop legs; that is, so that a free surface of starting sheet shall always be opposite the area covered by the supporting loop. The various methods of making this connection are illustrated in Fig. 3 and need no description. (1,269,458; June 11, 1918.)

**Ammonia Leaching.**—EARL T. STANNARD, of Kennebec, Alaska, patents a method whereby volatile solvents can be used in the leaching of ores, and extracted in such a manner that large losses in leached residues are avoided. Fig. 1 shows a typical instance of his process as applied to one lot of 600 tons of 1.5 per cent copper ore. He uses a closed leaching tank capable of being sealed and operated under pressure, with a steam inlet at the top and the usual filtering bottom. Approximately 1.1 pounds of ammonia are needed per pound of copper in the charge; in the illustration 125 tons of 8 per cent solution is indicated. The amount of solution varies with the fineness of the ore; a minimum amount being naturally desirable in order to reduce the total mass of liquids to be handled in process. After the rich solution has been drained from the ore, washing is done by introducing steam under pressure from above. This steam penetrates into the bed slowly, being condensed as it reaches cold ore, when the condensate trickles down, effectually washing before it the entrapped rich liquor. In this manner the copper salts in solution are kept ahead of the heated areas, thus obviating the danger of formation of insoluble copper compounds in the leach tank. When the total volume of ore has become permeated by live steam, the condensate ceases to flow—it having previously been added to the original filtrate—and the steam and ammonia it contains is then diverted to the surface con-

denser, where both are liquefied and returned to the new leaching solution. The amount of steam varies as the temperature of the ore, its nature and sizing, the depth of bed and the extraction of the solvent required; in the illustration, the steam is interrupted when the leached residues contain 0.05 pounds of ammonia per ton. This economical point of wastage varies with the relative cost of ammonia and steam. The leached residues are hot and contain but little moisture which readily evaporates when the tank is opened, giving a dry material which is easily handled. The rich solutions are boiled in a still, black oxide of copper being precipitated, ammonia being volatilized and condensed in suitable apparatus, and the boiled-out solution used to the required extent in making up fresh leaching solutions. (1,238,954; assigned to Kennecott Copper Corporation, Sept. 4, 1917.)

**Phosphorus from Molten Slag.**—The electric furnace smelting of a mixture of phosphates, sand and coke, with the accompanying reduction and distillation of phosphorus and its collection under water, has been in successful use for a decade. Mr. H. O. H. WENMAN of Bishop's Castle, England, patents passing molten slag direct from the iron furnace with sufficient silica and coke added, through an electric furnace, thereby accomplishing the old process with a saving in electric consumption of about 90 per cent. The reaction takes place at from 1300 to 1500 deg. C.



**Anode Suspension.**—JULIUS H. GILLIS, of Toronto, Ontario, notes the disadvantages of suspending anodes by upward projecting lugs. These remain as scrap for remelting, accidental breakage is common and they are difficult to cast. Lead suspensions are not desirable owing to the low tensile strength of the metal. Lead-covered suspension materially thicker than the anode cause growth of cathode crystals opposite any projecting portion, rapidly short circuiting the cell. The in-

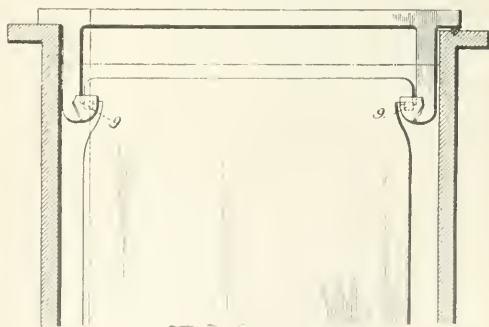


FIG. 4

ventor discovered that anode connectors of aluminium, somewhat of the shape shown in Fig. 4, overcome most of these difficulties, in that aluminium rapidly forms a continuous deposit of non-conducting salts when immersed in ordinary electrolytes. He casts a small block of copper 9 into the hanger so as to give a good metallic contact between hanger and cathode. (1,267,653; assigned to British America Nickel Corporation, Ltd.)



## Personal

MR. H. W. ALDRICH has resigned his position with the Anaconda Copper Mining Company to become assistant general superintendent of the Inspiration Consolidated Copper Company's plant at Miami, Ariz.

DR. SERGIO BAGNARA, metallurgist of the St. Joseph Lead Co. of Bonne Terre, Mo., has been appointed metallurgical engineer of the Ordnance Department. Dr. Bagnara is on his way to Washington, D. C., but expects to see service in France.

MR. HARRY B. CHAPMAN, formerly manager of the Chapman Engineering Co., Texas City, Texas, is now connected with the Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa.

MR. CHARLES Y. CLAYTON is now with the Bureau of Mines, Pittsburgh, Pa.

MR. E. P. DILLON is now general manager of the Research Corporation of New York. He was formerly manager of the power division, New York office, Westinghouse Electric & Manufacturing Co.

MR. C. E. DRAYER has been engaged as national secretary of the American Association of Engineers, Chicago, Ill., by the Board of Directors.

MR. W. C. EBAUGH has left Salt Lake City for Newark, Ohio, where he will become a member of the faculty of Denison University.

MR. J. H. FENTON, of the Los Angeles office of the Westinghouse Electric & Mfg. Company, has recently been appointed manager of the industrial division of that office, which includes jurisdiction over the Tucson and El Paso offices.

MR. H. M. FREEBURN has resigned as assistant engineer of the Pennsylvania State Department of Health to become associated with the engineering staff of Wallace & Tiernan Company, Inc., New York City, manufacturers of chlorine control apparatus and sanitary engineering specialties. Following his graduation from the Sanitary Engineering course of the Pennsylvania State College, Mr. Freeburn was an instructor at the institution and was in charge of experimental sewage work.

MR. R. R. HENDERSON, formerly chief chemist of the Vreeland Chemical Co., has resigned his position with that firm in order to devote his entire time to consulting practice. He now has his headquarters at Little Falls, N. J.

MR. ROBERT M. KEENEY has resigned as manager of The Ferro Alloy Co., Denver, Colo., to become general manager of The Iron Mountain Alloy Co., Denver, Colo.

MR. WILLIAM KOROTKIN has accepted a position in the engineering department of the Burro Mountain Branch of the Phelps-Dodge Corporation, Tyrone, New Mexico.

MR. J. N. MAHONEY, for 12 years a member of the engineering department, has tendered his resignation from the Westinghouse Electric & Mfg. Company, to open consulting offices in New York.

MR. B. MAGNUS has been commissioned captain in the Engineers Reserve Corps, and is now on active duty. He requests that all communications for him be sent care of Henry M. Toeh, 320 Fifth Ave., New York City.

MR. JOHN C. MERRILL is the successor to the firm of Sul-liger and Merrill, located at 1400 Ilibernian Building, Los Angeles, California.

MR. MERLE G. PETERSON is now connected with the Walter A. Zelnicker Supply Co.'s Chicago sales force at 428 First National Bank Building.

PROFESSOR J. H. RANSOM has been elected professor of chemistry and director of the chemical laboratories of Vanderbilt University at Nashville, Tenn. This university is considered to be the standard for college education in the South and the chemistry department is among the strongest in the university. Professor Ransom brings to his new

duties a wide and successful experience which must prove of advantage to the university and to the scientific education of the South. For a number of years Professor Ransom has been professor of general chemistry in Purdue University, and offered his resignation there just before the close of the school year just ended.

MR. H. J. SEAMAN of Catsauqua, Pa., formerly general manager of the Atlas Portland Cement Co., Northampton, Pa., has been appointed manager of the German-American Portland Cement Co., La Salle, Ill., by A. Mitchell Palmer, Alien Property Custodian.

MR. HENRY STROH has recently been added to the sales force of the Walter A. Zelnicker Supply Co., St. Louis, Mo. Prior to this he was connected with the Elliot Frog and Switch Company.

MR. T. AN. TESCH established on May 1, 1918, an engineering and construction office at Tumba, near Stockholm, Sweden. He will devote himself especially to the construction of modern iron and steel works, electric or non-electric.

MR. C. E. VAN BARNEVELD is in Denver, where he will remain for a time in connection with war-metal for the Bureau of Mines.

MR. CLAUDE C. VAN NUYS has resigned his position as professor of physics in the Colorado School of Mines and has removed to New York City, where he will be physicist for the Air Reduction Co.

MR. C. H. VONBAUR is now vice-president of the T. W. Price Engineering Co., Woolworth Bldg., New York City.

## Current Market Reports

### Non-Ferrous Metal Market

*Monday, August 26.*—Many metals go from producer to consumer via other channels than the open market, so that available supplies are in effect assigned with prices economically fixed and not fluctuating with the demand.

*Aluminium.*—The Government prices on ingots of 90 to 99 per cent Al are \$660 a ton f.o.b. plant in 50-ton lots, \$662 down to 15-ton lots and \$664 down to 1 ton, which prices will be effective for the remainder of this year. Prices per pound for small lots vary from 40 to 45c.; sheet aluminium, 18 ga. and heavier, 42c.; powdered aluminium, \$0.65 to \$3.00, according to mesh.

*Antimony.*—Increase of production costs in the Chinese mines due to present war activities in Asiatic Russia has resulted in a stronger buying demand and limited offerings. The price, duty paid, is now firm at 14% to 14%.

*Chrome.*—High-grade material is bringing a premium, 50 per cent ore selling at \$1.70 per unit.

*Copper.* The price of \$520 per ton has been continued by the War Industries Board for car load lots and 27.3c. per pound for smaller quantities. It is considered better to curtail nonessential consumption to obtain the Governmental requirements than to allow a sufficient price to make lean mines profitable.

|                                |        |          |
|--------------------------------|--------|----------|
| Copper sheets, hot rolled, lb. | \$0.36 | — \$0.37 |
| Copper sheets, cold rolled     | 37     | — 38     |
| Copper bottoms                 | 44     | — 45     |
| Copper rods                    | 36     | — 37     |
| Copper wire                    | 29     | — 30     |
| High brass wire                | 28     | — 29     |
| High brass sheets              | 28     | — 29     |
| High brass rods                | 26     | — 28     |
| Low brass wire                 | 32     | — 34     |
| Low brass sheets               | 32     | — 34     |
| Low brass rods                 | 33     | — 35     |
| Brazed brass tubing            | 37     | — 39     |
| Brazed copper tubing           | 42     | — 44     |
| Seamless copper tubing         | 41     | — 43     |
| Seamless bronze tubing         | 45     | — 46     |
| Seamless brass tubing          | 37     | — 39     |
| Bronze (gold) powder           | 1.00   | — 1.75   |

*Lead.*—The lead market is limited by selling restrictions. Producers must sell at a uniform and pre-arranged price. In car load lots at East St. Louis, the price is \$155 per ton. In New York, jobbers sell in jobbing lots at 8.55c. per pound plus cartage, though the wholesale price is still fixed at 8.05c. Full sheet lead, 10c.; cut sheets, 10½c.

**Manganese:**—Prices remain at \$1.35 per unit basis for better grades.

**Molybdenum:**—The price is \$1.00 per unit for 90 per cent MOS.

**Zinc:** Spelter is advancing. East St. Louis selling at from \$178, to \$182, per ton in car load lots. New York prices range between 9½ and 9¾ c. per pound; sheet zinc, 15c. and zinc dust, 16c. to 20c. per pound in 1600-lb. casts.

**Tin:**—Tin prices are declining, there being no large buyers on the open market and few dealers selling. Straits tin for September and October shipment from Singapore are offered at 79c. per pound subject to permit for consumption. About 3000 tons arrived during the first half of August. Tin for export from England has been quoted at 83c. and Banca at 84c. Spot tin is 88c. Babbitt metal varies between \$1.10 and 70c.; solder (50-50), 73c. per pound.

**Tungsten:**—High grade Wolframite and Scheelite with 92 tin, no copper and low manganese and over 70 per cent WO<sub>3</sub> is quoted at \$24 per unit.

**Silver:**—The Government has set a price of \$1.011 per troy ounce. This advance is due to the great amount of silver necessary to send to India to settle the European trade debit of \$360,000,000. As the world production of silver is only 172,000,000 ounces annually, Great Britain and the United States have been drawing on their silver currency. The Federal Reserve bank notes, our ninth form of monetary exchange, is now being introduced to release this great silver disbursement. Our army in Europe is now being paid in silver also.

#### OTHER METALS

|                                   |         |        |
|-----------------------------------|---------|--------|
| Bismuth, lb                       | \$3 50  | \$3 65 |
| Ca-Inium                          | 1 50—   | 3 50   |
| Cobalt                            | 2 50—   | 3 50   |
| Magnesium                         | 1 75    | 2 00   |
| Mercury, 75 lb                    | 175 00— |        |
| Mercury, lb                       | 1 95—   |        |
| Nickel, ingot, shot, electrolytic | 40      | 45     |
| Iridium, oz                       | 175 00— |        |
| Palladium, oz                     | 135 00— |        |
| Platinum, oz                      | 105 00— |        |

### The Iron and Steel Market

No important new regulations have been promulgated since last report for the distribution of pig iron and steel products. The system is regarded as practically perfect, and seems to be entirely satisfactory both to the War Industries Board and to the producers. What is unsatisfactory to both, and also to many buyers, including both jobbers and manufacturing consumers, is that the supplies are not sufficient to stretch to the less essential consumption purposes, let alone to those which are not recognized as entitled to any preference at all.

The whole thing, however, is a matter of viewpoint. In the last analysis it is eminently proper that the conditions viewed in various details should appear unsatisfactory. We are engaged in a great war. The soldier in the front line trench is quite dissatisfied. He should be in what is the enemy's front line trench, but if he were there the enemy's second line would be his objective.

There are set prices for iron and steel products, no competition. Competition is dead. There is the fiercest competition in the United States that has ever been experienced. It is of a different order. The American Navy is what it is to-day because it has always been the field of sharp competition, between men, gun crews, ships and fleets. There is competition between shell factories and forge shops, between forge shops and mills producing shell steel. Shipways launching hulls are competing with engine and boiler makers on the one hand and with steel mills supplying steel on the other. Each branch of each war activity is striving to move faster than others. The way to win the war is to take the view that shipbuilding is behind steel making, or steel making behind shipbuilding, not that the one is ahead of the other. Everything is in the wrong place that is not in the vanguard.

If the consumers whose activities are not particularly helpful in winning the war were receiving a full supply of steel, something would be altogether wrong. The war

activities should be able to consume that steel. It is precisely right that steel should be "scarce" from the viewpoint of the buyer who is accorded little or no preference by the regulations. That is the view taken even by those who experience the deprivation.

All things considered, the rate of steel production is very satisfactory by comparison with the conditions under which steel is produced. In June a rate of ingot production of 43,500,000 gross tons a year was attained. In July, with hot weather, the rate declined to about 42,250,000 tons, which is a smaller decline than usually occurs at this season of the year. August has perhaps developed a slightly lower rate, but better rates than 43,500,000 tons are expected later in the year. With the supply of scrap scant and the quality quite indifferent, with labor far from plentiful, and with multitudinous difficulties confronting furnaces and mills, the rate of production is on the whole very good. The existing ingot producing capacity is probably ratable at more than 47,000,000 tons a year with all conditions favorable but with conditions as they obtain, the lower rate is gratifying.

Demands for pig iron and steel to be shipped abroad, either for direct use by the A. E. F., or for repayment of material borrowed by General Pershing, or for new demands of our Allies, continue to increase. Additional car orders have been placed, together with orders for 200,000 tons of rails. Shell orders have been increasing, shipbuilding is speeding up week by week and new military wants are constantly developing.

The present trend is in the direction of further curtailment in the production of finished steel not directly involved in war work. Sheet mills, which have been operating at barely 60 per cent capacity, may be furnished somewhat less steel in future. The steel allotted to rod mills has decreased somewhat. Standard steel pipe manufacture has been on a somewhat reduced scale and the August distribution to jobbers is less than was expected. Merchant mills are allotted little more steel than enough to fill the higher priority orders, evidenced by the fact that the B-4 priority accorded to jobbers is not sufficient to give them much merchant bar tonnage.

Scarcely any class D steel is developing. The rule is one thing and operations under it are quite another thing. According to the regulations, if a manufacturer has material or manufacturing facilities beyond what is necessary to take care of priority orders and requirements of the preference list, the surplus becomes class D. The manufacturing facilities may be used and the material shipped in connection with a use not accorded preference, provided the manufacturer has the "permit" of the Director of Steel Supply "first had and obtained." The application must be made by the prospective producer, not by the prospective buyer. Apparently there is no harm in applying for permission to do something. One may then avail himself of the permission or not, as circumstances dictate. That is not the view of many steel producers, however, who reason that to apply for a permit to make and ship class D steel represents an admission that the thing can be done, and if it can be done, the War Industries Board may very properly hold the producer to the admission and require that the thing be done, that the steel be shipped for some war use, excuses not accepted. In other words, one may apply for a permit to ship 500 tons of class D steel and receive by return mail a priority order to ship 500 tons. Few permits are applied for and still fewer are granted. Some mills have slight surpluses of odds and ends but will probably use the material as scrap, to swell the production of war steel, rather than flirt with the permit system.

#### ABUSES OF SCRAP REGULATIONS

The very serious abuse of the scrap regulations as regards the purchase and scale of so-called "unguaranteed low phosphorus scrap" at \$34 when the price should be \$29 has been taken in hand in vigorous fashion by the authorities. The scrap committee of the American Iron and Steel Institute has issued a circular letter to all steel makers promising drastic action if the practice is not stopped and stating that existing contracts violating the provisions



should be canceled. The American Board of Scrap Iron Dealers has likewise issued a circular to its own members.

Low phosphorus scrap is No. 2 in the regulations, and three subdivisions are named, "C" being stated to cover "steel knuckles and couplers, rolled steel wheels, railway steel springs, carbon tool steel and material similar in quality and character." For this material \$34 may be paid for use in acid open-hearth furnaces. For ordinary heavy melting steel no more than \$29 may be paid.

The regulations were clearly worded and could not possibly be misunderstood by anyone of average intelligence. A trade had arisen, however, in what was called "unguaranteed low phosphorus scrap," the term being a pure fiction, and material that would hardly grade as heavy melting steel was being bought and sold at the \$34 price, much of it evidently intended for use in basic open-hearth furnaces. These evasions have not been altogether denied by the trade, but the argument has been used that the payment of the premium does not hurt the Government, as its purchases of finished steel products are at set limits. The argument overlooks the important fact that the payment of the premium reduces the profit of the mill, and as the Government is likely to tax the last \$5 of profits 80 per cent, there is ground for arguing that the payment of \$5 extra causes the mill to lose \$1 and the Government \$4.

### Chemical Market

**HEAVY CHEMICALS:**—The markets in general have been extraordinarily quiet, during the last few days in particular. Caustic and soda ash, which may be called the barometers of the trade, have been very inactive with a slight falling off in saccharine. As to dealers' profits in sulphuric, definite statement has been made by the authorities.

**Sulphur:**—The chemically pure floured product is subject to a very wide demand which, it is said, has increased 50 per cent over the normal, in view of which and remembering that the supply has been somewhat curtailed temporarily, some of the interests in the trade believe that this material will shortly see necessarily increased prices. Shipments are said to be coming in more slowly, confirming statements with regard to shortening of stocks. Nevertheless there has been no advance in prices during the week, as quotations continue on the basis of from \$4.35 to \$4.50 per hundred pounds f.o.b. New York.

**Sulphur Chloride:**—Orders for single jugs of this material are being quoted prices as high as 20c. per pound while in larger quantities from 15 to 19 and 20c. is asked. For the material in drums from 7½ to 9c. is the range of asking prices, depending upon the quantity and the buyer. Drums are extra and prices quoted f.o.b. New York.

**Epsom Salts:**—There is a good demand for this product but business lately has been of a very quiet character. Certain large producers have been compelled to withdraw from the market for the present owing to depletion of reserve stocks, but prices asked in other directions continue at from 3.40 to 3.50 f.o.b. New York with prices at the works holding 3c. in bags and 3¼c. in barrels for the U.S.P. material.

**Bleaching Powder:**—It has become practically impossible to locate spot holdings as even directions ordinarily in close touch with sources are themselves unable to accept orders for earlier than September shipment. The last sale reported was for shipment of material in from two to three weeks at 4½c. f.a.s.

**Potassium Permanganate of Potash:**—The market is very quiet with manufacturers continuing to quote 1.75 for the U.S.P. and from 1.30 to 1.50 for certain high-grade technical goods, although there are rumors of purchases at much below these figures.

**Dichromate of Soda:**—This market has seen a slight weakening although large factors state that sales have been consummated right along at 26c. Offerings of 24¼c. f.o.b. works have been made and contracts have been signed at 23¼c. Authorities, however, feel that the market will see a stiffening in a few days. Producers of soda from

the domestic chrome ore are asking 24¼c. The Caledonian chrome is not being imported directly but small quantities are coming in from time to time on vessels which use it for ballast on their return voyages; such quantities are small ton lots, however.

**Calcium Carbide:**—This market continues to hold at 19c. for September shipment, as spot lots are scarce. Exportations are limited by the lack of bottoms.

**Sodium Sulphide:**—Holdings are hard to find and inquiry is strong. Cars of spot material have changed hands at 8c. but offerings are now on the basis of 8½c.

**Carbon Bisulphide:**—Demand is steady with sales being made through the usual channels direct to consumers in most cases. Stocks are said to be sufficient to meet the requirements and prices therefore remain firm at 8c. per pound f.o.b. works.

**Caustic Soda:**—Transactions have been very few with the large inquiry on material rolling toward the Pacific coast on which prices are quoted 4.30 western works. Ex warehouse New York is quoted at 4.15.

**COAL TAR PRODUCTS:**—Very little change has taken place in these items as these markets have also been unusually quiet; saccharine perhaps showing the greatest activity with a slight falling off both in demand and price during the last few days.

**Phenol:**—Various prices are heard and some uncertainty in the trade as to just what the market may be in view of quotations from important directions at from 44 to 46c. and the knowledge that 43 or better may still be done. This latter price is quoted by directions having contracted some time ago and the higher prices quoted above apply to present business. Reports of scarcity are current with the result that prices are rather firm. It is not known that any new export licenses have been granted, the material going forward from time to time being upon licenses which had been revoked and later renewed.

**Benzol:**—Conditions remain the same with regard to offerings in tank car quantities at 23c. with certain directions willing to do business on the basis of 22c. on contract. For material in drums the level of 28c. continues to hold; but in view of the placing of large Government orders there is a general feeling that prices will see an appreciable advance in the Fall owing to a resulting shortage of stocks.

**Saccharine:**—A slight falling off is noted in the prices prevailing at this writing, attributed by some to the rumor that the British Government is to cancel all licenses and prohibit further importations of this product beginning Sept. 15, and another rumor which was heard to the effect that the government contemplated taking over the manufacturing. Largest factors in the manufacture state, however, that they have no knowledge of such intention on the part of the authorities. Soluble material is holding at the level of the last sales reported, 35.50, with insoluble available at 33.00. Very few sales are reported.

**Paraphenylenediamine:**—The demand for this material is fair with the prices showing a slight advance over those last reported, as from 4.00 to 4.50 is now asked depending upon grade and quantity. It is said that new manufacturers are about to enter the field and to produce a material of 99½ per cent. The C.P. product is almost unobtainable.

**Dimethylaniline:**—This market is not active and prices show no change. Supplies are said to be rather plentiful with quotations continuing to be made at 73c. spot, drums extra and nonreturnable.

**Dinitrophenol:**—There is very little of the material to be obtained as the factors in its production are directing their output to Government ends and have none but a very small quantity which may be offered in the open market at from 51 to 52c.

**Aniline Oil:**—Supplies are said to be getting more scarce with the natural result of a firmness noted in the market. From 28½ to 29c. for small lots is asked but on contract 28c. can still be done. In some directions 30 and 32c. are heard for large and small drums respectively.



## General Chemicals

WHOLESALE PRICES IN NEW YORK MARKET, AUG. 26 1918

|                                                   |         |               |         |
|---------------------------------------------------|---------|---------------|---------|
| Acetic anhydride                                  | lb.     | 1.60          | 1.85    |
| Acetone                                           | lb.     | 25 1/2        | 25 1/2  |
| Acetic acid, 28 per cent                          | cwt.    | 5.96          | 6.11    |
| Acetic, 50 per cent                               | cwt.    | 10.76         | 10.87   |
| Acetic, glacial, 99 1/2 per cent, carboys         | cwt.    | 19.00         | 19.20   |
| Boric, crystals                                   | lb.     | 1.34          | 1.15    |
| Hydrochloric, C. P.                               | lb.     | 85            | Nominal |
| Hydrofluoric, 30 per cent in barrels              | lb.     | .06           | .06 1/2 |
| Lactic, 44 per cent                               | lb.     | .15           | .16     |
| Lactic, 22 per cent                               | lb.     | .07           | .07     |
| Molybdo, C. P.                                    | lb.     | 6.90          | 7.40    |
| Nitric, 36 deg.                                   | lb.     |               | Nominal |
| Nitric, 42 deg.                                   | lb.     | .08 1/2       | .10     |
| Oralic, crystals                                  | lb.     | .42           | .44     |
| Phosphoric, 47-50 per cent paste                  | lb.     | .08           | .10     |
| Phosphoric, ref. 50 per cent                      | lb.     | .35           | .40     |
| Picric                                            | lb.     | .75           | .85     |
| Pyrogallol resublimed                             | lb.     | 3.25          | 3.50    |
| Sulphuric, 60 deg.                                | ton     | 18.00         |         |
| Sulphuric, 66 deg.                                | ton     | 28.00         |         |
| Sulphuric, oleum (Fuming), tank cars              | ton     | 60.00         | 65.00   |
| Tannic, U. S. P., bulk                            | lb.     | 1.30          | 1.50    |
| Tartaric, crystals                                | lb.     | .82           | .83     |
| Tungstic, per lb. of W.                           | lb.     | 1.70          | 1.75    |
| Alcohol, sugar, 188 proof                         | gal.    | 9 1/4         | 9 1/2   |
| Alcohol, wood, 95 per cent                        | gal.    | .68           | .69     |
| Alcohol, denatured, 180 proof                     | gal.    | .68           | .69     |
| Alum, ammonia lump                                | lb.     | .054          | .05 1/2 |
| Alum, chrome ammonium                             | lb.     | .20           | .21     |
| Alum, chrome potassium                            | lb.     | .20           | .21     |
| Alum, chrome sodium                               | lb.     | .12 1/2       | .13     |
| Alum, potash lump                                 | lb.     | .09 1/2       | .10     |
| Aluminium sulphate, technical                     | lb.     | .03 1/2       | .04     |
| Aluminium sulphate, iron free                     | lb.     | .03 1/2       | .04     |
| Ammonia aqua, 26 deg., carboys                    | lb.     | .12           | .16     |
| Ammonia, anhydrous                                | lb.     |               | Nominal |
| Ammonium carbonate                                | lb.     | 1.30          | 1.40    |
| Ammonium nitrate                                  | lb.     | (Fixed Price) | .15     |
| Ammonium sulphate domestic                        | lb.     | .07 1/2       | .08     |
| Amyl acetate                                      | gal.    | 5.30          | 5.35    |
| Arsenic, white                                    | lb.     | .09 1/2       | .17     |
| Arsenic, red                                      | lb.     | .65           | .70     |
| Barium carbonate, 99 per cent                     | ton     | 80.00         | 90.00   |
| Barium carbonate, 97-98 per cent                  | ton     | 65.00         | 67.00   |
| Barium chloride                                   | ton     | 65.00         | 70.00   |
| Barium sulphate (Blanco Fixe, Dry)                | lb.     | .044          | .05     |
| Barium nitrate                                    | lb.     | .12           | .14     |
| Benzon peroxide, 70 per cent                      | lb.     | .30           | .32     |
| Bleaching powder, 35 per cent chlorine            | lb.     | .02 1/2       | .03     |
| Borax, crystals, sacks                            | ton     | .07 1/2       | .10 1/2 |
| Brimstone, crude                                  | ton     | 65.00         | 70.00   |
| Bromine, technical                                | lb.     | .75           | .75     |
| Calcium, acetate, crude                           | lb.     | .74           | .05     |
| Calcium, carbide                                  | lb.     | .15 1/2       | .16     |
| Calcium chloride, 70-75 per cent, fused, lump     | ton     | 22.00         | 24.00   |
| Calcium chloride, 70-75 per cent, fused, granular | ton     | 1.50          | 1.70    |
| Calcium phosphate                                 | lb.     | .22           | .23     |
| Calcium sulphate 98-99 per cent                   | lb.     | .09           | .09 1/2 |
| Carbon bisulphide                                 | lb.     | .08           | .09     |
| Carbon tetrachloride, drums                       | lb.     | .14 1/2       | .13     |
| Carbonyl chloride (phosgene)                      | lb.     | 1.10          | 1.50    |
| Caustic potash, 88-92 per cent                    | lb.     | .63           | .77 1/2 |
| Caustic soda, 76 per cent                         | 100 lb. | 4.00          | 4.15    |
| Chlorine, liquid (Government Purchase)            | lb.     | (Fixed Price) |         |
| Cobalt oxide                                      | lb.     | 1.60          | 1.65    |
| Copperas                                          | lb.     | .02           | .02 1/2 |
| Copper carbonate                                  | lb.     | .30           | .31     |
| Copper cyanide                                    | lb.     | .75           | .75     |
| Copper sulphate, 99 per cent, large crystals      | lb.     | .09 1/2       | .09 1/2 |
| Cream of tartar, crystals                         | lb.     | .73           | .80     |
| Creosote salt, U. S. P.                           | lb.     | 3.40          | 3.50    |
| Formaldehyde, 37 per cent                         | lb.     | 1.64          | 1.74    |
| Glauber's salt                                    | lb.     | .02           | .03     |
| Glycerine, bulk, C. P.                            | lb.     | .62           | .65     |
| Iodine, resublimed                                | lb.     | 4.25          | 4.35    |
| Iron oxide                                        | lb.     | .13           | .15     |
| Lead acetate, white crystals                      | lb.     | .15 1/2       | .16 1/2 |
| Lead arsenate (Paste)                             | lb.     | .15           | .18     |
| Lead nitrate                                      | lb.     |               | Nominal |
| Litharge, American                                | lb.     | .11 1/2       | .14     |
| Lithium carbonate                                 | oz.     | 1.50          | 2.05    |
| Magnesium carbonate, technical                    | lb.     | .14           | .15     |
| Nickel salt, white gran.                          | lb.     | .14           | .15     |
| Nickel salt, double                               | lb.     | .12           | .13     |
| Phosgene, (see Carbonyl chloride)                 | lb.     | 1.10          | 1.50    |
| Picric, resublimed                                | lb.     | 1.15          | 1.20    |
| Phosphorus, yellow                                | lb.     | 1.02          | 1.13    |
| Potassium bichromate                              | lb.     | .45           | .46     |
| Potassium bromide granular                        | lb.     | 1.35          | 1.36    |
| Potassium carbonate refined, 85-90 per cent       | lb.     | .35           | .38     |
| Potassium chlorate, crystals                      | lb.     | .40           | .41     |
| Potassium cyanide, 98-99 per cent                 | lb.     | .60           | .70     |
| Potassium iodide                                  | lb.     | .37 1/2       | .38     |
| Potassium murate 80-85 p. c. basis of 80 p. c.    | 300.00  | 350.00        |         |
| Potassium nitrate                                 | lb.     | .27           | .31     |
| Potassium permanganate U. S. P.                   | lb.     | 1.30          | 1.75    |
| Potassium persulfate, red                         | lb.     | 2.30          | 2.50    |
| Potassium prussiate, yellow                       | lb.     | .97           | 1.00    |
| Potassium sulphate, 90-95 p. c. basis 90 p. c.    | ton     |               | Nominal |
| Rochelle salts                                    | lb.     | .44 1/2       | .46     |
| Salammoniac, gray gran                            | lb.     | .22           | .23     |
| Salammoniac, white gran.                          | lb.     | .17           | .20     |
| Salt soda                                         | 100 lb. | 1.40          | 1.65    |
| Salt cake                                         | ton     | 35.00         | 40.00   |
| Silver cyanide, based on market price of silver   | oz.     | .62 1/2       | .64 1/2 |
| Silver nitrate                                    | lb.     | .23           | .26     |
| Soda ash, 58 per cent, light, flat (Lago)         | 100 lb. | 2.50          |         |
| Soda ash, 58 per cent, dense, flat                | 100 lb. | 3.40          | 3.85    |
| Sodium acetate                                    | lb.     | .30           |         |
| Sodium bicarbonate, domestic                      | lb.     | .01 1/2       | .02 1/2 |
| Sodium bicarbonate, English                       | lb.     | .23 1/2       | .26     |
| Sodium bichromate                                 | lb.     | .06           | .07     |
| Sodium bisulphite, powd.                          | lb.     | .25           | .25 1/2 |
| Sodium chlorate                                   | lb.     | .40           | .42     |
| Sodium cyanide                                    | lb.     | .17           | .18     |
| Sodium fluoride, commercial                       | lb.     | .40           |         |

|                                        |         |         |         |
|----------------------------------------|---------|---------|---------|
| Sodium hyposulphite                    | lb.     | 2.60    | 3.60    |
| Sodium molybdate, per lb. of Mo.       | lb.     | 2.50    |         |
| Sodium nitrate, 95 per cent            | 100 lb. | 4.12    | 5.00    |
| Sodium nitrite                         | lb.     | .27     | .30     |
| Sodium peroxide                        | lb.     | .35     | .45     |
| Sodium phosphite                       | lb.     | .04     | .04 1/2 |
| Sodium prussiate, yellow               | lb.     | .75     | .52     |
| Sodium silicate, liquid (60 deg.)      | lb.     | .02 1/2 | .03 1/2 |
| Sodium sulphide, 30 per cent, crystals | lb.     | .04 1/2 | .04 1/2 |
| Sodium sulphide, 60 per cent, fused    | 100 lb. | 8.50    |         |
| Sodium sulphite                        | lb.     | .23 1/2 | .06     |
| Strontium nitrate                      | lb.     | .30     | .30     |
| Sulphur chloride, drums                | lb.     | .07 1/2 | .09     |
| Sulphur dioxide, liquid, in cylinders  | lb.     | .15     | .40     |
| Sulphur, flowers, sublimed             | 100 lb. | 4.70    | 4.50    |
| Sulphur, roll                          | 100 lb. | 3.70    | 3.85    |
| Sulphur, crude                         | ton     | 65.00   | 70.00   |
| Tin bichloride, 50 deg.                | lb.     | .28     | .29     |
| Tin oxide                              | lb.     | .18     | .20     |
| Zinc carbonate                         | lb.     | .15     | .15 1/2 |
| Zinc chloride                          | lb.     | .15     | .15 1/2 |
| Zinc cyanide                           | lb.     |         | Nominal |
| Zinc dust, 350 mesh                    | lb.     | .13 1/2 | .14     |
| Zinc oxide, American process XX        | lb.     | .13     | .14     |
| Zinc sulphate                          | lb.     | .04 1/2 | .06 1/2 |

## Coal Tar Products (Crude)

|                                        |                    |      |       |
|----------------------------------------|--------------------|------|-------|
| Benzol, pure, water white              | gal.               | .22  | .28   |
| Benzol, 90 per cent                    | gal.               | .25  |       |
| Toluol, in tank cars                   | gal. (Fixed Price) | 1.50 |       |
| Toluol, for non-military use, in drums | gal. (Fixed Price) | 1.55 |       |
| Xylol, pure, water white               | gal.               | .45  |       |
| Solvent naphtha, water white           | gal.               | .18  | .25   |
| Solvent naphtha, crude, heavy          | gal.               | .12  | .15   |
| Cresote oil, 25 per cent               | gal.               | .45  | .50   |
| Dip oil, 20 per cent                   | gal.               | .30  | .32   |
| Pitch, various grades                  | ton                | 8.00 | 20.00 |
| Carbolic acid, crude, 95-97 per cent   | lb.                | 1.05 | 1.10  |
| Carbolic acid, crude, 50 per cent      | lb.                | .60  | .65   |
| Carbolic acid, crude, 25 per cent      | lb.                | .35  | .38   |
| Cresol, U. S. P.                       | lb.                | .19  | .20   |

## Intermediates, Etc.

|                              |     |       |          |
|------------------------------|-----|-------|----------|
| Alpha naphthol, crude        | lb. | 1.00  | 1.10     |
| Alpha naphthol, refined      | lb. | 1.50  | 1.60     |
| Alpha naphthylamine          | lb. | .60   | .62      |
| Aniline oil, drums extra     | lb. | .28   | .30      |
| Aniline salts                | lb. | .45   | .45      |
| Anthracene, 80 per cent      | lb. |       | Nominal  |
| Benzaldehyde (f.f.c.)        | lb. | 3.75  | 4.00     |
| Benzenidine, base            | lb. | 1.60  | 1.85     |
| Benzenidine, sulphate        | lb. | 1.40  | 1.45     |
| Benzoic acid, U. S. P.       | lb. | 2.65  | 2.85     |
| Benzoate of Soda, U. S. P.   | lb. | 2.65  | 2.85     |
| Benzyl chloride              | lb. | 2.65  | 2.50     |
| Beta naphthol benzoate       | lb. | 10.00 | 12.00    |
| Beta naphthol, sublimed      | lb. | .85   | .90      |
| Beta naphthylamine, sublimed | lb. | 2.65  |          |
| Dichlor benzol               | lb. | .15   | .20      |
| Diethylaniline               | lb. | 4.00  | 4.50     |
| Dinitro benzol               | lb. | .36   | .38      |
| Dinitrochlorobenzol          | lb. | .40   | .45      |
| Dinitrophenol, alpha         | lb. | .55   | .60      |
| Dinitrotoluol                | lb. | .65   | .75      |
| Dimetaphenol                 | lb. | .55   | .60      |
| Dimethylaniline              | lb. | .70   | .78      |
| Diphenylamine                | lb. | 1.00  | 1.10     |
| H-acid                       | lb. | 3.00  | 3.40     |
| Metaphenylenediamine         | lb. | 1.85  | 2.05     |
| Monochlorobenzol             | lb. | .09   | .20      |
| Naphthalene, flake           | lb. | .20   | .20 1/2  |
| Naphthalene, balls           | lb. | .11   | .12      |
| Naphthionic acid, crude      | lb. | 1.20  | 1.30 1/2 |
| Naphthylamine-sulphonic acid | lb. | 1.50  | 1.10     |
| Nitro naphthalene            | lb. | .45   | .50      |
| Nitro toluol                 | lb. | .55   | .60      |
| Ortho-amidophenol            | lb. | .15   | .20      |
| Ortho-dichlor-benzol         | lb. | .95   | 1.10     |
| Ortho-toluidine              | lb. | .75   | .85      |
| Ortho-nitro-toluol           | lb. | 4.00  | 4.50     |
| Para-amidophenol, base       | lb. | 4.25  | 5.00     |
| Para-amido-phenol, H. Ch.    | lb. | 1.50  | 2.00     |
| Para-dichlor-benzol          | lb. | 1.70  | 1.85     |
| Paranitraniline              | lb. | 1.50  | 1.60     |
| Para-nitro-toluol            | lb. | 3.75  | 4.00     |
| Paraphenylenediamine         | lb. | 2.00  | 2.25     |
| Para-toluidine               | lb. | 4.00  | 4.50     |
| Phthalic acid anhydride      | lb. | .45   | .46      |
| Phenol, U. S. P.             | lb. | 5.50  | 7.00     |
| Resorcin, technical          | lb. | 8.00  | 9.00     |
| Resorcin, pure               | lb. | .88   | 1.00     |
| Salicylic acid               | lb. | .32   | .34      |
| Sulphanilic acid, crude      | lb. | 2.50  | 3.00     |
| Tolidio                      | lb. | .85   | .90      |
| Tolidine-mixture             | lb. | .85   | .90      |

## Petroleum Oils

Crude (at the Wells)

|                       |      |      |      |
|-----------------------|------|------|------|
| Pennsylvania          | bbl. | 4.00 |      |
| Corning, Ohio         | bbl. | 2.85 |      |
| Esromet, Ky.          | bbl. | 2.68 |      |
| Waco, Ohio            | bbl. | 2.68 |      |
| Indiana               | bbl. | 2.28 |      |
| Illinois              | bbl. | 2.42 |      |
| Oklahoma and Kansas   | bbl. | 2.42 |      |
| Caddo, La., light     | bbl. | 2.25 |      |
| Corleane, Tex., light | bbl. | 2.25 |      |
| California            | bbl. | 1.57 |      |
| Gulf Coast            | bbl. | 1.90 |      |
| Mexican               | bbl. | 1.90 |      |
| Fuel Oil              |      |      |      |
| New York              | gal. | .15  |      |
| Philadelphia          | gal. | .10  |      |
| Baltimore             | gal. | .07  | 1.41 |
| Pittsburgh            | gal. | .07  | 1.10 |
| Texas                 | bbl. | 1.85 | 2.35 |
| Los Angeles           | bbl. | 1.60 |      |

## Gasoline (Wholesale)

|                    |      |     |   |     |
|--------------------|------|-----|---|-----|
| New York.....      | gal. | .24 | — | .25 |
| Gas machine.....   | gal. | .41 | — | —   |
| 72-76 degrees..... | gal. | .33 | — | .39 |
| 70-72 degrees..... | gal. | .30 | — | —   |
| 68-70 degrees..... | gal. | .30 | — | .36 |
| Pittsburgh.....    | gal. | .25 | — | —   |
| Chicago.....       | gal. | .22 | — | .23 |
| Oklahoma.....      | gal. | .22 | — | —   |
| San Francisco..... | gal. | .20 | — | .21 |

## Paraffine Waxes

|                                  |     |     |   |     |
|----------------------------------|-----|-----|---|-----|
| Crude, 103 to 105 deg. m.pt..... | lb. | .08 | — | .09 |
| Crude, 118 to 120 deg. m.pt..... | lb. | .09 | — | .10 |
| Crude, 124 to 126 deg. m.pt..... | lb. | .10 | — | —   |
| Refined, 120 deg. m.pt.....      | lb. | .13 | — | —   |
| Refined, 128 deg. m.pt.....      | lb. | .14 | — | —   |
| Refined, 135 deg. m.pt.....      | lb. | .16 | — | .16 |
| Ozokerite, brown.....            | lb. | .75 | — | —   |
| Ozokerite, green.....            | lb. | .85 | — | —   |

## Lubricants

|                                                  |      |     |   |     |
|--------------------------------------------------|------|-----|---|-----|
| Black, reduced, 29 gravity, 25-30 cold test..... | gal. | .23 | — | .24 |
| Cylinder, light.....                             | gal. | .42 | — | .43 |
| Cylinder, dark.....                              | gal. | .39 | — | .41 |
| Paraffine, high viscosity.....                   | gal. | .40 | — | .41 |
| Paraffine, 903 sp. gr.....                       | gal. | .36 | — | .38 |
| Paraffine, 885 sp. gr.....                       | gal. | .26 | — | .28 |

## Flotation Oils

(Prices at New York unless otherwise stated)

|                                                                          |      |     |   |     |
|--------------------------------------------------------------------------|------|-----|---|-----|
| Pine oil, crude, f. o. b. Florida.....                                   | gal. | .44 | — | —   |
| Pine oil, steam-distilled, sp. gr. 0.925-0.940.....                      | gal. | .58 | — | .60 |
| Pine oil, destructively distilled.....                                   | gal. | .58 | — | .60 |
| Pine-tar oil, sp. gr. 1.02-1.035.....                                    | gal. | .35 | — | —   |
| Pine-tar oil, double refined, sp. gr. 0.965-0.990.....                   | gal. | .42 | — | —   |
| Pine-tar oil, ref., light, sp. gr. 0.950, tank cars, f. o. b. works..... | gal. | .37 | — | —   |
| Pine-tar oil, ref., heavy, sp. gr. 1.025, tank cars, f. o. b. works..... | gal. | .28 | — | —   |
| Pine-tar oil, ref., thin, sp. gr. 1.060-1.080.....                       | gal. | .32 | — | —   |
| Turpentine, crude, sp. gr. 0.870-0.900.....                              | gal. | .45 | — | —   |
| Hardwood oil, f. o. b. Michigan, sp. gr. 0.960-0.990.....                | gal. | .23 | — | —   |
| Hardwood oil, f. o. b. Michigan, sp. gr. 1.06-1.08.....                  | gal. | .43 | — | —   |
| Wood creosote, ref. f. o. b. Florida.....                                | gal. | .31 | — | —   |

## Naval Stores

|                                               |               |       |   |       |
|-----------------------------------------------|---------------|-------|---|-------|
| Rosin A-E barrel.....                         | 280 lb.       | 11.85 | — | 11.90 |
| Rosin F-I.....                                | 280 lb.       | 11.95 | — | 12.35 |
| Rosin K-N.....                                | 280 lb.       | 13.75 | — | 14.00 |
| Rosin W-G-W.....                              | 280 lb.       | 14.10 | — | 14.25 |
| Spirits of turpentine.....                    | gal.          | .61   | — | .62   |
| Wood turpentine, steam distilled.....         | gal.          | .63   | — | —     |
| Wood turpentine, destructively distilled..... | gal.          | .65   | — | —     |
| Pitch.....                                    | bbbl. 200 lb. | 5.50  | — | —     |
| Tar, kils dried.....                          | 280 lb.       | 12.50 | — | —     |
| Retort tar.....                               | 280 lb.       | 13.50 | — | —     |
| Rosin, first run.....                         | gal.          | .63   | — | —     |
| Second run.....                               | gal.          | .66   | — | —     |
| Third run.....                                | gal.          | .69   | — | —     |
| Fourth run.....                               | gal.          | .79   | — | —     |

## Vegetable Oils

|                               |      |      |   |      |
|-------------------------------|------|------|---|------|
| Castor oil.....               | lb.  | .28  | — | .30  |
| China wood oil.....           | lb.  | .30  | — | .32  |
| Cocao nut oil.....            | lb.  | .18  | — | .21  |
| Corn oil.....                 | lb.  | .18  | — | —    |
| Cottonseed oil, crude.....    | lb.  | .20  | — | .22  |
| Linseed oil, raw, cars.....   | gal. | 1.88 | — | 1.90 |
| Olive oil.....                | gal. | 4.50 | — | 4.75 |
| Peanut oil, crude.....        | lb.  | .18  | — | .22  |
| Soya bean oil, Manchuria..... | lb.  | .16  | — | .18  |

## Miscellaneous Materials

|                                          |         |       |   |       |
|------------------------------------------|---------|-------|---|-------|
| Barytes, floated, white, foreign.....    | ton     | 38.00 | — | 42.00 |
| Barytes, floated, white, domestic.....   | ton     | 25.00 | — | 37.00 |
| Beeswax, white, pure.....                | lb.     | .36   | — | .37   |
| Beeswax, unbleached.....                 | lb.     | .43   | — | .46   |
| Blanc fixe.....                          | lb.     | .07   | — | —     |
| Cacoin.....                              | lb.     | .07   | — | .28   |
| Ceylon graphite.....                     | lb.     | .07   | — | .25   |
| Chalk, light, precipitated, English..... | lb.     | .04   | — | .06   |
| China clay, imported, lump.....          | ton     | 20.00 | — | 40.00 |
| China clay, domestic, lump.....          | ton     | 15.00 | — | 22.50 |
| Feldspar.....                            | ton     | 8.00  | — | 12.00 |
| Fluorspar, gravel, f. o. b. mines.....   | ton     | 60.00 | — | —     |
| Fluorspar, washed, powdered.....         | ton     | 90.00 | — | —     |
| Fuller's earth, powdered.....            | 100 lb. | 1.50  | — | 2.00  |
| Juanan wax.....                          | lb.     | .24   | — | .25   |
| Mexican graphite.....                    | ton     | 75.00 | — | —     |
| Madagascar graphite.....                 | lb.     | .10   | — | .15   |
| Orange shale.....                        | lb.     | .70   | — | .76   |
| Pumice stone.....                        | lb.     | .04   | — | .08   |
| Red lead, dry, carloads.....             | lb.     | .10   | — | .11   |
| Soaps.....                               | ton     | 15.00 | — | 25.00 |
| Stearic acid, 120 deg. m.pt.....         | lb.     | .13   | — | —     |
| Stearic acid, 140 deg. m.pt.....         | lb.     | .19   | — | —     |
| Talc, American, white.....               | ton     | 20.00 | — | 40.00 |
| White lead, dry.....                     | lb.     | .09   | — | .10   |

## Glues

|                                 |      |      |   |      |
|---------------------------------|------|------|---|------|
| Extra white.....                | lb.  | .36  | — | .45  |
| Cabinet.....                    | lb.  | .31  | — | .40  |
| Brown foot stock.....           | lb.  | .18  | — | .22  |
| Fish glue, 50-gal. barrels..... | gal. | 1.00 | — | 1.60 |

## Refractories, Etc.

(F. O. B. Works)

|                                       |          |        |   |        |
|---------------------------------------|----------|--------|---|--------|
| Chrome brick.....                     | net ton  | 175.00 | — | —      |
| Chrome cement.....                    | net ton  | 75.00  | — | —      |
| Clay brick, lat quality fireclay..... | per 1000 | 50.00  | — | 55.00  |
| Clay brick, second quality.....       | per 1000 | 35.00  | — | 40.00  |
| Magnesite, raw.....                   | ton      | 30.00  | — | 35.00  |
| Magnesite, calcined, powdered.....    | ton      | 50.00  | — | 65.00  |
| Magnesite, dead burned.....           | net ton  | 50.00  | — | 60.00  |
| Magnesite brick, 94x2x2.....          | net ton  | 110.00 | — | 125.00 |
| Silica brick.....                     | per 1000 | 50.00  | — | 60.00  |

## Ferrous alloys

|                                                                          |     |        |   |        |
|--------------------------------------------------------------------------|-----|--------|---|--------|
| Ferrocobalt, 15-18 per cent, carloads, f. o. b. Niagara Falls, N. Y..... | ton | 200.00 | — | 250.00 |
| Ferrocobalt.....                                                         | lb. | 15.00  | — | 30.00  |
| Ferrocobalt, per lb. of Cr.....                                          | ton | 250.00 | — | —      |
| Ferromanganese, domestic, 70 per cent basis.....                         | ton | 325.00 | — | —      |
| Ferromanganese, English.....                                             | ton | 75.00  | — | —      |
| Spiegel Eisen (16-18%).....                                              | ton | 4.00   | — | 4.50   |
| Ferromolybdenum, per lb. of Mo.....                                      | ton | 180.00 | — | 190.00 |
| Ferrosilicon, 75 per cent, f. o. b. N. Y.....                            | ton | 160.00 | — | 170.00 |
| Ferrosilicon, 50 per cent, carloads, del. Pittsburgh.....                | lb. | 7.50   | — | —      |
| Ferrosilicon, 50 per cent, contract.....                                 | ton | 2.35   | — | 2.40   |
| Ferrotungsten, 75-85 per cent, f. o. b. Pittsburgh.....                  | lb. | 7.50   | — | —      |
| Ferrotungsten, f. o. b. works, per lb. of U.....                         | ton | —      | — | —      |
| Ferrovanadium, f. o. b. works.....                                       | lb. | —      | — | —      |

## Ores and Semi-finished Products

|                                                                |      |       |   |        |
|----------------------------------------------------------------|------|-------|---|--------|
| Antimony ore, per unit.....                                    | ton  | 1.50  | — | 1.55   |
| Chromite ore, 45 per cent minimum, f. o. b. Cal. per unit..... | ton  | 1.20  | — | —      |
| Chromite ore, 45 per cent and over, New York, per unit.....    | ton  | 80.00 | — | 100.00 |
| Manganese ore, 48 per cent and over, per unit.....             | ton  | 1.25  | — | —      |
| Manganese ore, chemical.....                                   | ton  | 24.00 | — | —      |
| Molybdenite, per lb. of Mo.....                                | ton  | 24.00 | — | —      |
| Tungsten, Scheelite, per unit of WO.....                       | ton  | 24.00 | — | —      |
| Tungsten, Wolframite, per unit of WO.....                      | ton  | 10.50 | — | 3.60   |
| Uranium oxide, 96%.....                                        | lb.  | 3.25  | — | —      |
| Vanadium pentoxide, 99%.....                                   | lb.  | 17.00 | — | 17.00  |
| Pyrites, foreign.....                                          | unit | 28    | — | 30     |
| Pyrites, domestic.....                                         | unit | 28    | — | 30     |

## Plant Supplies

## BUILDING MATERIALS

|                                              |         |        |   |        |
|----------------------------------------------|---------|--------|---|--------|
| Common clay bricks.....                      | M       | 13.00  | — | 14.00  |
| Hollow tile, 4 x 8 x 12.....                 | M       | 60.00  | — | —      |
| Hollow tile, 12 x 12 x 12.....               | M       | 170.00 | — | —      |
| Lime.....                                    | ton     | 16.50  | — | —      |
| Portland cement.....                         | bbbl.   | 59     | — | —      |
| Single glass (82-lb.), 10 x 26-16 x 24.....  | M       | 21.00  | — | 27.00  |
| Double glass (164-lb.), 10 x 26-16 x 29..... | M       | 31.00  | — | 39.00  |
| Yellow pine lumber.....                      | M       | 39.00  | — | 45.00  |
| Fir lumber.....                              | M       | 31.00  | — | 35.00  |
| Hemlock.....                                 | M       | 24.50  | — | 40.00  |
| Tarred felt (14-lb. sq.).....                | ton     | 64.00  | — | —      |
| Roofing pitch.....                           | ton     | 14.00  | — | 22.00  |
| Asphalt coated roofing (35-55-lb. sq.).....  | sq.     | 1.75   | — | 1.84   |
| State surfaced asphalt shingles.....         | sq.     | 5.25   | — | 5.50   |
| Corrugated galvanized iron.....              | ton     | 109.00 | — | 127.00 |
| Putty.....                                   | 100 lb. | 6.75   | — | 20.00  |
| Red oxide (Ppte. Copperas).....              | 100 lb. | 15.00  | — | —      |
| Native red oxide.....                        | 100 lb. | 3.25   | — | 8.00   |
| Red metallic paint.....                      | 100 lb. | 1.20   | — | 1.50   |
| White lead in oil.....                       | 100 lb. | 15.50  | — | 11.42  |
| Red lead in oil.....                         | 100 lb. | 13.00  | — | 14.50  |
| Zinc oxide (dry).....                        | 100 lb. | 9.00   | — | 10.00  |
| Zinc oxide—leaded.....                       | 100 lb. | 1.50   | — | 10.00  |
| Yellow ochre.....                            | 100 lb. | 14.00  | — | 50.00  |
| Ultra marine blue.....                       | 100 lb. | 135.00 | — | 150.00 |
| Prussian blue.....                           | 100 lb. | 40.00  | — | 70.00  |
| Chrome green.....                            | 100 lb. | 43.00  | — | 49.00  |
| Paris green.....                             | 100 lb. | 17.00  | — | 2.25   |
| Mineral black.....                           | 100 lb. | 4.50   | — | 12.00  |
| Powdered bone black.....                     | 100 lb. | 15.00  | — | 45.00  |
| Lampblack.....                               | 100 lb. | 16.00  | — | 25.00  |
| Gas carbon.....                              | 100 lb. | 1.00   | — | 2.00   |
| Manganese petroleum pitch.....               | 100 lb. | 2.00   | — | 2.50   |
| Gilsonite.....                               | 100 lb. | .40    | — | 1.00   |
| Coal tar pitch.....                          | 100 lb. | .40    | — | 1.00   |

## STRUCTURAL IRON

|                                           |     |        |   |        |
|-------------------------------------------|-----|--------|---|--------|
| Blue annealed sheet iron.....             | ton | 84.00  | — | 89.00  |
| Black sheet iron.....                     | ton | 96.00  | — | 104.00 |
| Galvanized iron.....                      | ton | 105.00 | — | 170.00 |
| Terne plate, 8-lb. coating.....           | ton | 150.00 | — | —      |
| Terne plate, 15-lb. coating.....          | ton | 200.00 | — | —      |
| Terne plate, 25-lb. coating.....          | ton | 240.00 | — | —      |
| Terne plate, 40-lb. coating.....          | ton | 155.00 | — | —      |
| Tin plate, prime.....                     | ton | 60.00  | — | 70.00  |
| Tank plates.....                          | ton | 60.00  | — | 65.00  |
| Channels, channels, angles, T's, Z's..... | ton | 88.00  | — | 92.00  |
| Rivets.....                               | ton | 51.00  | — | —      |
| Steel pipe, 1 to 3-inch.....              | ton | 60.00  | — | 70.00  |
| Bar iron and steel.....                   | ton | 13.00  | — | —      |
| Chains (1 inch proof coil).....           | ton | 70.00  | — | 80.00  |
| Nails, bolts, nuts, washers.....          | ton | 300.00 | — | 500.00 |
| Tin steels, special alloys.....           | ton | 37.25  | — | —      |
| Beamers pig iron.....                     | ton | 47.50  | — | —      |
| No. 2 foundry.....                        | ton | 33.50  | — | —      |
| Steel billets (4 x 4).....                | ton | 47.50  | — | —      |

## POWER HOUSE SUPPLIES

|                                   |     |      |   |      |
|-----------------------------------|-----|------|---|------|
| Steam packing, rubber duck.....   | lb. | .99  | — | 1.10 |
| Asbestos, high pressure.....      | lb. | 1.76 | — | —    |
| Asbestos, wired.....              | lb. | 1.30 | — | —    |
| Asbestos, graphited braid.....    | lb. | 1.75 | — | —    |
| Asbestos, wire.....               | lb. | .66  | — | —    |
| Rubber, sheet.....                | lb. | .07  | — | —    |
| Cup grease.....                   | lb. | .07  | — | —    |
| Transmission grease.....          | lb. | .04  | — | —    |
| Asx grease.....                   | lb. | .04  | — | —    |
| Gear grease.....                  | lb. | .08  | — | .13  |
| Cotton waste.....                 | ft. | .75  | — | —    |
| Hose, underwriters, 2 1/2 in..... | ft. | .30  | — | .60  |
| Hose, air, 1 in.....              | ft. | .30  | — | —    |

# INDUSTRIAL NEWS

## Plant Construction—Catalogs—New Publications

### Construction and Operation

#### Alabama

**WOODWARD.**—The Woodward Iron Co. will build a plant to manufacture steel products principally for Government steamship construction. Estimated cost, \$25,000,000.

#### California

**AZUSA.**—The Aul Fumigating Co. will build a plant for the manufacture of cyanide. Estimated cost between \$100,000 and \$150,000. Irving Dingle, manager.

**LOS ANGELES.**—The City Council voted to permit to the people at the fall election a proposition to vote on \$130,000 bonds for the construction of sewage system and treatment plant at the Wilmington Harbor District. A. C. Hansen, City Engineer.

#### Colorado

**DENVER.**—L. M. Styles, has purchased a site at 4th and Navajo Sts., on which he will build a plant for the manufacture of mica.

**PEARL.**—E. H. Lobdell, will build a 50-ton mill to treat ore from the Wolverine mine.

#### Connecticut

**BRIDGEPORT.**—The Union Metallic Cartridge Co., Railroad Ave., has awarded the contract for the construction of a two-story, 60 x 240 ft., concrete, brick and steel factory, concrete foundation, to the T. J. Pardy Construction Co., 15 Fairfield Ave. Estimated cost, \$35,000.

**HARTFORD.**—The Hartford Rubber Co., Park St., has awarded the contract for the construction of a two-story, 60 x 100 ft., rubber factory on Bartholomew Ave., to J. H. Grozier Co., 721 Main St. Estimated cost, \$35,000.

**HARTFORD.**—Henry Souther Engineering Co., 11 Laurel St., has awarded the contract for the construction of a two-story, 35 x 35 and 35 x 15 ft., brick laboratory to Porteus Walker Co., 13 Forest St., Hartford. Estimated cost, \$15,000. Noted Aug. 15.

**OKAWVILLE.**—The Autotype Co. will build a 14-story, 49 x 110 ft., addition to its factory. Estimated cost, \$20,000. Guion Thompson, 27 West Main St., engineer.

**STAMFORD.**—Baer Brothers, 700 Canal St., has awarded the contract for the construction of a 5-story, 75 x 115 ft., reinforced concrete, brick and steel factory for the manufacture of bronze powder, to Thompson & Binger Inc., 230 Madison Ave., New York City. Estimated cost, \$175,000.

#### Florida

**GAINESVILLE.**—The Gillett Oil Co., 1015 Citizens Bank Building, Tampa, has taken over the plant of the Florida Industrial Corporation and will operate it as a castor oil plant under Government control.

**JACKSONVILLE.**—The American Agricultural Chemical Co., Herald Building, has awarded the contract for the construction of a two-story, 240 x 401 ft., reinforced concrete plant for the manufacture of fertilizer, to the Turner Construction Co., 241 Madison Ave., New York City. Noted Aug. 15.

**TAMPA.**—The War Dept., Washington, D. C., will build a plant to manufacture phosphorus for screening ship and troop equipment, to 26 1/2-kw., electric power. W. C. Lockwood, Hillsboro Hotel, investigating for site.

#### Illinois

**GRANITE CITY.**—The National Enameling & Stamping Co. will build a 1-story, 100 x 200 ft., reinforced concrete, brick and steel lime burning plant. Estimated cost, \$100,000. Engineering Service Corporation, Railway Exchange Building, St. Louis, Mo., engineers.

#### Indiana

**NEW ALBANY.**—The Calumet Fertilizer Co. has awarded the contract for the con-

struction of a 1-story, 100 x 250 ft., reinforced concrete, brick and steel factory, to the Austin Co., 1611 Euclid Ave., Cleveland, Ohio. Estimated cost, \$60,000.

#### Iowa

**GARNER.**—City will build a system of sanitary sewers and a sewage disposal plant. J. G. Thorne, 317 Howes Block, Clinton, town engineer.

#### Kansas

**BAXTER SPRINGS.**—The Hoeker Development Co., Miami, Okla., will build a 175-ton concentration plant and is in the market for mill lumber, roofing, gas engine, belts, sludge and slime tables, drills and air compressors. Estimated cost, \$60,000. M. W. Pysher, superintendent.

#### Louisiana

**MONROE.**—The Republic Gas & Carbon Co., Reading, Pa., will build a carbon plant here.

#### Maryland

**BAITIMORE.**—The Maryland Color Printing Co., Holliday and Hillen Sts., has awarded the contract for the construction of a 6-story, 83 x 120 ft., reinforced concrete addition to its plant to the Consolidated Engineering Co., 243 Calvert Bldg.

**BAITIMORE.**—The United States Public Health Service, will build a hospital building and fumigating plant at Quarantine here.

#### Michigan

**HIGHLAND PARK.**—City will install filter equipment superstructure and piping. Estimated cost, \$75,000. L. C. Whitsett, City Hall, engineer.

**SAGINAW.**—The General Motors Corporation will build a foundry plant for the manufacture of automobile castings to consist of a 163 x 440 ft. foundry, 100 x 400 ft. core building, 110 x 265 ft. cleaning room, 100 x 120 ft. pattern shop and storage building. Estimated cost, \$1,100,000. F. D. Chase, Inc., 122 South Michigan Ave., Chicago, Ill., engineer.

**SAGINAW.**—The Saginaw Malleable Iron Co., Center and Salt Sts., has awarded the contract for the construction of a 140 x 400 ft. foundry, to J. S. Kerns, Detroit, Mich. Estimated cost, \$125,000.

#### Mississippi

**PASCAGOULA.**—The City will equip a sewage disposal plant, with accessory requirements. Estimated cost, \$100,000. F. Johnson, Mayor.

#### Missouri

**BELL CENTER.**—The Bankers Mining Co. has awarded the contract for the construction of a 100-ton concentration plant to A. Jeffcott, Joplin. Estimated cost, \$50,000. The company is in the market for steam engine, boilers, crushers, sludge and slime tables, roofing, lumber, air compressors, drills, belts, pipes and hardware, conveyors, track and ore cars.

**DUEWEG.**—The Silver Plume Mining Co. will remodel its 200-ton concentration plant and is in the market for sludge and slime tables, mill hardware, lumber, drill, ore cans and car track. Estimated cost, \$25,000. H. W. Logan, Danvers, superintendent.

**JOPLIN.**—The Big Elk Mining Co. will build a 250-ton concentration plant and is in the market for sludge and slime tables, crushers, mill hardware, lumber, air compressors and engine, boilers. Estimated cost, \$65,000. L. R. Elester, Kansas City, superintendent.

**KANSAS CITY.**—The Upjohn Co., 22nd and Oak Sts., leased a 3-story building and will install machinery to increase the output of chemicals.

**ST. LOUIS.**—The Johnson Tin Foli & Metal Co., 6030 South Broadway, has awarded the contract for the construction of a 2-story, concrete plant to March Construction Co., Railway Exchange Building. Estimated cost, \$35,000.

**ST. LOUIS.**—The La Cede Gas Light Co., 11th and Olive Sts., will build a 1-story, 200 x 1200 ft., steel plant for the manufacture of munitions. G. B. Evans, engineer.

#### New Jersey

**CAMDEN.**—The Concrete Steel Co., Pennsylvania Building, Philadelphia, Pa., will build a 1-story, 50 x 120 ft., addition to its plant at Delaware Ave. and Pearl St.

**PATERSON.**—The Mazzarella Piece Plying Co., 176 Sheridan Ave., has awarded the contract for the construction of a dye house to Stephen Meshier & Son, 92 Albion Ave. Estimated cost, \$4000.

**TREREN.**—The Shaw Pottery Co., Park Ave., will build a 1-story, 35 x 60 ft., addition to its plant.

#### New York

**BUFFALO.**—The Lumen Bearing Co., 167 Lathrup St., will build a 1-story addition to its brass foundry. Estimated cost, \$5000.

**BUFFALO.**—The National Aniline & Chemical Co., Edgewood Arsenal, has awarded the contract for the construction of a 1-story, 40 x 52 and 80 x 80 ft., reinforced concrete, brick and steel plant on Buffalo River, to J. W. Cowper Co., 44 Fidelity Building. Estimated cost, \$75,000.

**BUFFALO.**—The Prest-O-Lite Co., 206 Amsterdam Ave., New York City, will build a plant on Hopkins St. and Colgate Ave., here which will consist of four units.

**CORNING.**—The Corning Glass Works will build a 3-story, 60 x 120 ft. addition to its plant on Walnut St.

**ROCHESTER.**—The Symington Anderson Co., Cutler Building, will build a 1-story, 40 x 118 ft., addition to its plant on University Ave., for the manufacture of guns. Estimated cost, \$15,000.

#### Ohio

**BUYCRUS.**—The American Clay Machinery Co., will build a 1-story, 100 x 250 ft., reinforced concrete, brick and steel factory. Estimated cost, \$60,000.

**CLEVELAND.**—The American Bronze Honor Roll Co., 944 West 23rd St., New York City, will build a 2-story, concrete and brick factory here. Estimated cost, \$25,000.

**CLEVELAND.**—The Buckeye Bronze Manufacturing Co., 1807 Columbus Road, will build a foundry.

**CLEVELAND.**—The Central Brass Co., 6200 Cedar Ave., has awarded the contract for the construction of a 1-story, 35 x 72 ft., reinforced concrete and brick foundry at 6203 Cedar Ave., to Munk Gibbons, 5309 Prospect Ave. Estimated cost, \$7500.

**CLEVELAND.**—The City has authorized the Director of Public Utilities to expend a sum not to exceed \$100,000 for chemicals for the Division of Water.

**CLEVELAND.**—The Var Oil & Paint Co., 929 Schofield Building, has awarded the contract for the construction of a 1-story, 45 x 100 ft., reinforced concrete, brick and steel factory to the Austin Co., 16112 Euclid Ave. Estimated cost, \$25,000.

**JOHNSTOWN.**—The city will build a garbage disposal plant and sewage disposal plant. Estimated cost, \$75,000. J. W. Cramer, city clerk.

**LORAIN.**—The City has awarded the contract for the construction of filter bottoms and manifold castings for waterworks improvements, to the Pittsburgh Filter Co., Farmers Bank Building, Pittsburgh, Pa. Estimated cost, \$100,000.

**TOLEDO.**—Maternity & Childrens Hospital, will build a 1-story, 45 x 125 ft., reinforced concrete and brick hospital on Summit St., to include a pathological laboratory. Estimated cost, \$100,000. G. E. Rheinfrank, 601 Gardner Building, engineer.

**TOLEDO.**—The Toledo Furnace Co., Front St., will build a foundry, two factory buildings and a laboratory, reinforced concrete, brick and steel. Estimated cost, \$100,000. F. Warner, 768 Hippodrome Bldg., architect.

**WARREN.**—The International Steel Tube & Rolling Mills, will build six rolling mills and steel tube mills. Estimated cost, \$500,000.

**YOUNGSTOWN.**—The Struthers Furnace Co., Bridge St., has awarded the contract for the construction of a slag crushing plant, capacity 500 tons, to Eaker, Dunbar, Allen Co., Union Arcade, Pittsburgh, Pa.

#### Oklahoma

**CARNRY.**—City will build a gas plant. Estimated cost, \$1500. Address the Mayor.



**DOLTHAT.**—The Forth National Lead and Zinc Co., will build a 250-ton concentration plant and is in the market for motors, engines, boilers, sludge tables, belts, lumber, mill hardware, drills, air compressors and conveyors. Estimated cost, \$65,000. J. H. Morris, superintendent.

**McALESTER.**—The City will build a sewage disposal plant. Estimated cost, \$110,000. J. M. Gannaway, City Clerk.

**MIAMI.**—The Lead Roy Mining Co., will remodel and enlarge its 250-ton concentration plant and is in the market for gas engine, sludge and slime tables, crushers, belts, air compressors, drills and mill hardware. Estimated cost, \$25,000. R. H. Elkins, Miami, superintendent.

**PICHER.**—The Cortez Mining Co., Miami, will build a 250-ton concentration plant and is in the market for sludge and slime tables, gas engine, lumber, mill hardware, crushers, air compressors, conveyors and belts. Estimated cost, \$65,000. W. T. Landrum, superintendent.

**PICHER.**—The Hidden Treasure Co., will build a 350-ton concentration plant and is in the market for sludge and slime tables, motors, air compressors, crushers, lumber, hardware, roofing and conveyors. Estimated cost, \$65,000. C. S. Campbell, Baxter Springs, superintendent.

**QUAPAW.**—The Red Rose Mining Co., will build a 200-ton concentration plant and is in the market for crushers, lumber, mill hardware, belts, pipe, air compressors, ore cars, track and conveyors. Estimated cost, \$65,000.

**ST. LOUIS.**—The Kansas Line Mining Co., will build a 300-ton concentration plant, and is in the market for sludge and slime tables, lumber, mill hardware, roofing, engines, belts, air compressors, crushers. Estimated cost, \$65,000. W. A. Meese, superintendent.

## Oregon

**PENDELTON.**—The City will build a septic tank for the sewerage. Estimated cost, \$25,000. Geary Kimbrell, city engineer.

**WALWALA.**—The City will build a sanitary trunk sewer and sewage disposal plant.

## Pennsylvania

**GREENVILLE.**—The Sharon Waterworks Co., will extend its filtration plant and beds at the pumping station where a 5,000,000 gallon pump will be installed.

**LYKEN.**—The American Briquet Co., Drexel Building, will build a 1-story, 50 x 225 ft., briquetting plant. Estimated cost, \$200,000. Kern Dodge, 1512 Morris Building, architect.

**PHILADELPHIA.**—Wm. Cramp & Sons, Ball and Beach Sts., has awarded the contract for the construction of a 1-story, 50 x 220 ft., brick and steel coppersmith shop on Richmond and Morris Sts. to Asa Moore, Bulletin Building. Estimated cost, \$31,000.

## South Carolina

**COLUMBIA.**—The City will build an additional coagulating basin on the hill east of the old basin, increasing the total capacity to 12,000,000 gallons of filtered water daily. T. K. Legare, city engineer.

## Texas

**CARLEBAD.**—City will build a sanitary sewage disposal plant for the State Tuberculosis Sanatorium. J. B. McKnight, superintendent.

**DALLAS.**—The Trinity Products Co., will rebuild its guerciton plant, recently destroyed by fire entailing a loss of \$100,000.

**ELECTRA.**—City has awarded the contract for the construction of a sewer system and a 1000-gal. water tank. Estimated cost, \$130,000. D. J. Howell & Son, Union Trust Building, Washington, D. C., engineers.

**HILLSBORO.**—City will build a sewage disposal plant. Estimated cost, \$25,000.

**HOUSTON.**—The Empire Gas & Fuel Co., will build an oil refinery on ship channel.

**LAREDO.**—The Laredo Water Co. will improve the waterworks and install a filtration plant.

**SAN ANTONIO.**—Geo. B. Ellgestern, San Antonio, and H. H. Todd, Gainesville, will build an oil refinery. Estimated cost, \$350,000.

## Virginia

**ALEXANDRIA.**—The Alexandria Water Co., will build a gravity filtration plant, daily capacity 2,000,000 gal. Estimated cost, \$130,000. D. J. Howell & Son, Union Trust Building, Washington, D. C., engineers.

**CLINCHFIELD.**—The International Coal Products Corporation, 24 Broad St., New York City, will build a plant for the manu-

facture of carbocool. The Clinchfield Carbocool Corporation being organized will operate the plant to distill coal to recover toluol, benzol, naphtha, ammonia, creosote, etc. and manufacture residue into fuel briquets. The plant is under Government supervision.

**RICHMOND.**—The Chesapeake & Ohio Ry. Co. will build a 100 x 400 ft. plant for the manufacture of nitrogen, oxygen, acetylene and other gases. K. T. Crawley, industrial engineer.

**RICHMOND.**—The Chesapeake & Ohio Ry. Co. has awarded the contract for the construction of a 1-story, 52 ft. 10 in. x 244 ft. brick and steel brass foundry, to Arnold & Co., 105 South La Salle St., Chicago, Ill. Estimated cost, \$50,000.

## Washington

**SEATTLE.**—The Kilbourne-Clarke Manufacturing Co., 24 West Connecticut St., has awarded the contract for the construction of a wireless-manufacturing plant consisting of a 1-story, 100 x 300 ft. machine shop, 2-story, 60 x 100 ft. store house, 1-story, 60 x 100 ft. laboratory, and a 2-story, 60 x 60 ft. office building, at 3450 East Marginal Way, to Fred Woodman, Seattle. Estimated cost, \$80,000.

## West Virginia

**LINN.**—The Monongahela Valley Traction Co., Parkersburg, will build a gas-producer plant.

## Wisconsin

**CUBA.**—The National Zinc Ore Separating Co., will build an acid plant. C. Barker, superintendent.

**NEW DIGGINGS.**—The Skinner Roaster Co., Benton, will build an acid plant to be operated under government supervision. Estimated cost, \$750,000.

## Canada

### British Columbia

**VANCOUVER.**—The Dominion Forestry Service, Journal Building, Ottawa, will build an aeroplane spruce testing laboratory, jointly with the University of British Columbia and the Provincial Government. E. H. Campbell, Journal Building, Ottawa, director.

**VANCOUVER.**—J. W. McFarlane, 1053 Nelson St., will build a fertilizer plant.

## Ontario

**BRAMPTON.**—The City will build a sewage disposal plant. W. M. Treadgold, town engineer.

**KIRKHAM LAKE.**—Wright Hargraves will install a mill at his mine.

**PEMBROKE.**—The Thomas Hink Co., will rebuild its munitions plant recently destroyed by fire, entailing a loss of about \$200,000.

**WINDSOR.**—City will build a filtration plant.

**WINGHAM.**—The Farmers Fertilizer Co. will build a fertilizer plant. Estimated cost, \$8000.

## Quebec

**AMOS.**—The Penn-Canadian Mining Co., Cohasset, Ore., will build a 30-ton concentration plant. B. Nelly, manager.

**LEVIS.**—The city will build a filtration plant. Estimated cost, \$100,000. Edouard Hamel, St. Peter St., engineer.

**VERDUN.**—The British Munitions Co., Ltd., Kings Park, has awarded the contract for the construction of an addition to its shell factory, to E. G. M. Cape & Co., Ltd., 10 Cathcart St. Estimated cost, \$30,000.

## Industrial Notes

**THE METALS DISINTEGRATING CO., INC.**, announces the removal of its offices from South William Street to 82 Broadway, New York City.

**THE METAL & THERMIT CORPORATION'S** Toronto office is now at 15 Emily Street.

**THE DEARBORN CHEMICAL CO., Chicago**, has inaugurated a special sales department for the manufacture and marketing of a number of specialties. One is a rust preventive known as No-Ox-Id, to keep metal parts or finely finished surfaces of the completed machines free from corroding. Another specialty is a cutting oil for use in metal cutting, quenching oils for heat treating, drawing oils and Dearboline, a preparative for cleaning machined parts of emery or grease.

**THE SARCO CO., INC.**, New York City, has opened a new office in Atlanta, Ga., in the Healey Building under the management of C. R. Dunwoody.

**THE JONATHAN BARTLEY CRUGIBLE CO.**, Trenton, N. J., had a fire in Plant No. 2 recently but they wish to announce that all business will be taken care of as though nothing had happened and orders will be delivered as specified with very few exceptions. Arrangements have been made and orders placed for the necessary machinery and equipment and the company expects to be in full operation under its own roof by November 1.

**THE LINCOLN ELECTRIC CO.**, Cleveland, Ohio, has taken an order from the Ordnance Department for 53 150-amp. arc welding machines which will be in demand in connection with portable machine shops carried on motor trucks.

**THE AKTIEBOLAGET FORJUS SMÅLVERKS** Co. proposes to build two electric iron-smelting furnaces this summer, which will make a total of three. The company's power is secured from the Forjus waterfall, power is not used from the Forjus waterfall.

**THE CONNELLSVILLE FOUNDRY, MACHINE & STEEL CASTINGS CO.**, iron and steel castings and special machinery, has discontinued the sales office formerly maintained at 801 Park Building, Pittsburgh. All correspondence should be addressed to the general office at Connelville, Pa.

**THE MCKINNEY STEEL CO.**, Cleveland, Ohio, is erecting four open-hearth furnaces of 65-ton capacity and two more soaking pits, making a total of 16 open hearth furnaces.

**THE CHICAGO PNEUMATIC TOOL CO.** announces that contract has been let and work started on the erection of an up-to-date addition to their Cleveland plant, which is planned to double the present output. It is expected that the work will be completed on the building itself about November first. The necessary equipment has been ordered and it is believed will be delivered and ready for installation about the time the building is completed so that the additional production contemplated will be available very soon thereafter.

**THE RADIUM ORE SAMPLING CO.** announces the completion of a \$12,000 custom sampler at Montrose, Colorado, for the sampling of such ores as uraniferous and concentrates. The plant is equipped particularly for the careful handling of carnotite. The company does not assay, purchase or deal in ores or their products.

**THE BOOTH-HALL CO.**, 565 West Washington Blvd., Chicago, Illinois, has contracts for building Booth-Hall electric steel furnaces for the following companies: Consumers Steel Company, Chicago, Illinois, three 3-ton electric open hearth furnaces, and for the Ecorse Foundry & Machine Company, Ecorse, Michigan, one 3-ton furnace for producing steel castings.

**T. AN. TESCH** has taken over the Aktiebolaget Elektrometall which holds the patents on electric furnaces for pig iron now in operation in Sweden and other countries. He is desirous of getting in communication with American concerns contemplating the construction of modern iron and steel plants, electric or non-electric.

The newly formed **NORDBOTTENS JÄRNVERKS AKTIEBOLAGET** will construct a new plant at Lulea in northern Sweden consisting of 1 or 14 electric blast furnaces, corresponding charge works, hot metal plants, and houses for officers and employees. The necessary power will be contracted from the Swedish government at the rate of 1000 kw. The plant is controlled by the owners of iron and steel plants in central Sweden for the purpose of procuring electric pig iron to be refined at their respective works or be obtained from the Lapidland district. The plant which is being designed by T. An. Tesch will be one of the world's largest electric pig iron producers.

## New Publications

**THE JOURNAL OF THE AMERICAN CERAMIC SOCIETY** Volume 1, No. 1, with date of January, 1918, has recently appeared. The Journal is published by the members of the American Ceramic Society and takes the place of the volume of transactions containing the papers presented at the annual meetings. By reason of the high standard of the American Ceramic Society the new journal may be expected to take first place as the exponent of the arts and sciences applied to silicate industries. George H. Brown, Rutgers College, New Brunswick, N. J., is editor.

# CHEMICAL & METALLURGICAL ENGINEERING

A consolidation of ELECTROCHEMICAL & METALLURGICAL INDUSTRY and IRON & STEEL MAGAZINE

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### Miss Liberty Is On the Wire

SUPPOSE you were sitting safe and comfortable at your desk—busy of course, but nevertheless very safe and comfortable compared with a night raider in No Man's Land—suppose you were sitting there and your 'phone should ring and your operator should tell you that "Miss Liberty is on the wire." You would be interested, wouldn't you? And then if a calm, firm voice should say "Hello, this is LIBERTY speaking; billions of dollars are needed, and needed NOW"—what would your answer be? Would you feel embarrassed? Would you halt or stammer? Would you be too surprised to answer? Or would you speak up promptly as though answering a call you were expecting?

Beginning September 28 and continuing for three weeks, Liberty is going to speak throughout the length and breadth of the land, and her message is going to be the same everywhere—"Billions of dollars are needed, and needed NOW!" Through the instrumentality of the colored supplement which accompanies this issue of CHEMICAL AND METALLURGICAL ENGINEERING we are trying to aid Uncle Sam in getting a connection with every loyal American. Literally and in fact, Liberty has a long-distance call in for YOU from France. Have you the answer ready?

### Win-the-War Meetings for Fourth Liberty Loan

WE PUBLISH on advertising pages 310 and 311 the announcement of a plan for securing the organized coöperation of all employers of labor in the promotion of the Fourth Liberty Loan. We have given the subject valuable space because we deem it worthy of attention. In view of the fact that it has potential consequences far beyond the success of the loan, or even the winning of the war, we have no hesitancy in urging employers to act upon the suggestions there made.

It is well known that nothing is so effective in securing hearty coöperation in an organization as a feeling of personal responsibility among its members. Nothing is so potent for harmonious achievement of big results as a sense of personal pride among those who make the results possible. The tremendous impetus which Mr. Schwab has given to shipbuilding is due largely to a recognition of these facts; and he has accomplished the result by coming in personal contact with the workers and inspiring them with his own sense of the importance of their work in winning the war. Every employer, can, in like manner, be a leader of his own group of men and a center of influence that cannot be



overestimated. The means to this end is one or more win-the-war meetings of the employer with his employees; and the way in which the plan can be carried out systematically is described in the program booklet mentioned in the announcement. If the plan proves effective for the immediate purpose of promoting a Liberty Loan, why may it not be equally so for all industrial purposes after the war? The idea is worth a trial.

### Rehabilitating Wounded and Crippled Soldiers

THE casualty lists are coming in fast and among the severely wounded there are many who will return with defective equipment in the way of legs and arms. The Government has very wisely planned to avoid, if possible, the pension errors of the days which succeeded the Civil War, and to provide in the place of them the greatest measure of rehabilitation of those that are crippled, so that they may take their places in the community. It is a bad thing to encourage idleness.

We must get over all prejudice against crippled men as a class and it behooves us to find places for those who have been physically injured but who are willing and able to work. Artificial legs and arms have been remarkably developed and we shall address ourselves for the present to a consideration of the industrial employment of one-legged and one-armed men. The blind belong in a different category.

Artificial legs made of hollow willow and leather are so articulated that a man with even two stumps can walk rapidly and for long distances. Physically, a great deal depends upon the stump. Most of these are easy to fit but occasionally there is one that always gives trouble. While a man with one or two wooden legs would seldom be an ideal porter or wheelbarrow operator, usually he can stand up and walk and do a man's work. Again, the one-armed man, properly fitted, is far better off than he used to be. Artificial arms are designed to meet special purposes and it is surprising the number of tools with which these may be equipped. They are not made to look like normal limbs. Some of them are wicked looking members, but are nevertheless remarkably efficient instruments. For ordinary occasions the cripple is provided with a "dress arm" which is an imitation of a normal arm and gloved hand.

Of course it all depends upon the man. There was an Irish lad who lost both legs, his left arm and all the fingers of his right hand in the great blizzard of '86 in New York. When he came out of the hospital they sent him to the poor-house. He told the authorities that if they would support him for a year while he was getting the education he needed he would take care of himself, but if they wouldn't he was resolved to live to be ninety and to make them take care of him all the time. They let him have his way and now he is president of a large bank in Minnesota. He drives his own automobile and even lights his cigar when he smokes. A man with such resolution is bound to succeed. We can't get that kind very often. Some men, as soon as they lose a member, proceed to become self-pitying nuisances, and of these not one in a hundred is worth his salt. But more often, it is said, men with artificial limbs develop an unusual quality of patience. They stick tighter than others to the problem in hand because

they have had the training in patience as grown men to learn the art of using artificial limbs. Their employment is especially indicated in working at processes that need careful watching.

The American Red Cross has undertaken a rehabilitation institute for men injured in industrial and other accidents, taken from the hospitals. They are easily placed at present. But the time is near when such men will be coming out by the thousand. They must be employed if an unwholesome and bad situation is to be avoided. We therefore recommend to our readers that they look about their establishments and make note of the places where returned crippled soldiers may be employed. The records should be constantly studied and made available when the time comes for us to take care of our heroes and to make life worth while to them.

### Change in Meeting of Electrochemical Society

WE ARE advised as we go to press that the American Electrochemical Society has been obliged to change the place of its Fall meeting from Princeton University to Atlantic City, due to the fact that the War Department has taken charge of the University. The meeting will be held as scheduled, Sept. 30 to Oct. 2, with headquarters at the Hotel Traymore.

### Wanted: Information on Blast-Furnace Smelting

IN THE present issue appears a paper on slag control in the iron blast-furnace in which is elaborated the practical applications of the author's slag-viscosity tables recently published by the Bureau of Mines. The thesis advanced is most important; it is that the chemical reactions in the smelting zone depend upon the "active range"—the interval between the temperatures of entrapment and escapement of iron globules in the slag—and that the fuel consumption of the blast-furnace varies directly with the temperature where the iron works itself free from the slag bath. Obviously a slag with a wide active range and yet labile at a relatively low temperature is the one desired in these days of actual and prospective coke famine. The slag-viscosity tables enable the metallurgist to select scientifically the optimum composition fitting his slag-forming ingredients.

This rather novel conception of furnace action has much to commend itself to the theorist speculating upon the reactions proceeding in the smelting zone of the blast-furnace. It throws welcome light upon the reactions of carburization and silicification and may explain the peculiar characteristics of electric pig iron. But ready acceptance may be somewhat delayed on at least one consideration which merits close attention.

Feild's conception of slag action rests upon the assumption that the molten iron is imprisoned in the just-forming slag when viscosity of the latter reaches a value of approximately 10. For the time one may readily accept the oft-repeated statement that the reduction of iron oxide attains completion quite high in the furnace shaft at a low temperature (possibly 800 deg. C.). The present hypothesis implies that carbonization and sulphidation of the spongy mass should also proceed



at about the same temperature. At 1135 deg. C. the austenite-cementite eutectic melts, and with the settlement of the charge it is superheated and readily dissolves any excess metallic constituent. Therefore at 1400 deg. C., the approximate temperature at which the slag reaches a viscosity of 10, the iron has doubtless all fused into fiery drops, and it is very difficult to see how this liquid metal can become trapped in the slowly moving slag; any hardly expects water bubbles to be absorbed in warm tar. Oozing slag certainly will engulf solid fragments, but can it absorb drops of thin liquid?

However one may feel about the "trapped iron" hypothesis, a consideration of the subject opens up most interesting questions on carbonization and sulphidation reactions, on the mechanism of slag formation, on the physical characteristics of many oxides at high temperatures, on the temperature-concentration equilibrium of many important reactions, and on the relation of viscosity to reversible reactions at interfaces. The solution of these cannot fail to be most fruitful in tangible results to scientists as well as works-metallurgists. It is to be hoped that the Bureau of Mines may not only continue the attack upon such fundamental lines, but endeavor to initiate and coordinate individual effort on the part of investigators in many university and research laboratories.

### Ship Losses and Ship Construction

ACCOUNTS of the performance of shipyards are likely to create an unduly favorable impression as to the extent to which the destruction of vessels by submarines is being met. Many of the reports published are more or less fragmentary, frequently referring to the performance of a single week. Launching of hulls has lately exceeded by a large margin the actual completion and delivery of vessels. The production of ship plates has greatly exceeded the quantity that has actually gone into hull construction. Ship construction by the United States or the United Kingdom has sometimes been compared with the vessel losses of the same countries, whereby there is left out of the reckoning the important item of losses by neutrals being far in excess of their vessel construction. Finally, vessel losses are reported in gross register tons while vessel construction is reported in deadweight tons, while roundly speaking it requires about 125 tons deadweight to be built to make up for 100 gross tons lost. The public mind has been confused by the inadequacy of the presentations and the net result of the confusion is to create an impression that combating the submarine by new construction has proceeded farther towards success than is really the case.

The total of allied and neutral vessel losses through enemy action and marine risks since the war began are as follows, in gross tons, including 182,829 tons of Allied shipping interned in enemy ports at the opening of the war:

| Year                | Gross Tons |
|---------------------|------------|
| 1914 .....          | 681,363    |
| 1915 .....          | 1,724,720  |
| 1916 .....          | 2,797,866  |
| 1917 .....          | 6,623,623  |
| 1918 (Seven months) | 2,396,590  |
| Total .....         | 14,224,162 |

Thus the losses have amounted to almost 30 per cent of the world's merchant marine and obviously it is no small task to replace the tonnage. Now, what was the impression created in the average mind by the announcement made in Washington September 4 by the Shipping Board, that shipbuilding in the United States in August broke all records for any country for a month? A very favorable impression, no doubt. The record, however, was of 340,145 tons deadweight of vessels completed, that breaking the American record of 263,571 tons in May, and the British record of 295,911 tons in June. It compares, moreover, with a January output of 88,507 tons by the United States and 37,852 tons by the United Kingdom. The proper conception is that if American shipbuilding in August broke the records, that is so much the worse for the records.

The record of 340,145 tons deadweight completed by shipyards in the United States in August represents no more than about 280,000 gross tons, for comparison with the gross tonnage of vessels lost. At this record rate it would require 50 months for the shipyards of the United States to make up for the vessel losses from the beginning of the war to August 1, 1918. If our August tonnage broke the British record, the indication would be that the British contribution would not be sufficient to cut the time in half.

The Shipping Board began operations in August, 1917. From the beginning to August 1, 1918, the deliveries on its account have been 245,700 tons deadweight of contract vessels and 1,326,156 tons of requisitioned vessels, making a total of 1,571,856 tons deadweight, equivalent to less than 10 per cent of the total losses of 14,000,000 gross tons.

The purpose of these comparisons is merely to show that the job of replacing vessel losses is still to be done. The facts that Great Britain broke her record as lately as last June, and with only 295,911 tons, and that the United States broke her record as lately as August, with only 340,145 tons, show that the job has only been fairly undertaken.

A great deal of information as to what is required in order to build ships has been obtained. For instance, when we severed relations with Germany in February, 1917, we thought steel plates were unobtainable and directed our attention to wooden hulls because we had a great many trees. The wooden-ship chimera died a hard death. The condition for weeks past has been that plate mills are delivering, for account of shipbuilding in the United States, a quantity equal to 650,000 tons deadweight of vessels per month, yet 340,145 tons deadweight of vessels completed in August, barely more than one-half as much, broke the record, and some of the vessels were not steel at that. The launchings in July had been 631,944 tons. Plates, of which 18 months ago we thought we had none available, are in plentiful supply. The bottle-neck is equipment, engines, boilers and a thousand and one other things, as the Director of Shipbuilding plainly and frankly stated recently. The job lies before us and the speeding-up still needed is chiefly on the part of shops all over the country that must furnish engines, boilers, cranes and all sorts of equipment of a dozen other descriptions with which to furnish the hulls.

## Readers' Views and Comments

### Science and the German Language

To the Editor of Chemical & Metallurgical Engineering

SIR:—Anent your most interesting editorial on the use of the German language at present, might it not be well to allow the study of German, stamping on every German page the following:

This language has some admirable characteristics but it has certain notable defects such as lack of any true word for gentleman, sportsman or sincerity.

In this connection, we might say that the German word for sportsman is simply a Germanized form and is pronounced *Schporhtman*; the word for gentleman is *Herr* which means lord or master; the word for sincerity is *Aufrichtigkeit* which means uprightness. These are poor, lame substitutes for our words and both in denotation and connotation have quite different meanings.

CHEMIST.

### Organic Reagents for Research Purposes

To the Editor of Chemical & Metallurgical Engineering

SIR:—I am interested in the letter of Dr. Mees of the Eastman Kodak Co., relative to their manufacture of organic chemicals. In this connection your readers will doubtless be glad to know that the Research Laboratory of Chicago is principally engaged in the manufacture of such products. We are now making in small quantities a series of organic reagents and will begin work in the near future on a series of acridine dye-stuffs which have proved successful in chemotherapy.

G. HEYL.

Chicago, Ill.

### Evaluation of Zinc Dust

To the Editor of Chemical & Metallurgical Engineering

SIR:—In looking over my copy of CHEMICAL & METALLURGICAL ENGINEERING of July 1, I note the reprint of my paper on the Evaluation of Zinc Dust, read at the last meeting of the American Society for Testing Materials. I wish to direct your attention to two errors which appeared in this paper as follows:

1—The correction tube as shown on page 33 of your magazine for July should not be closed at the bottom. The accompanying sketch will show this in its correct form.

2—At the bottom of the first column on page 33 the sentence beginning, "The temperature change, on the other hand, . . . according to Boyle's law," should read, "The temperature change, on the other hand, . . . according to Charles' law."

I suggest that you make these corrections in an early issue of your magazine in order that your readers may have no misunderstanding regarding the article.

LOUIS A. WILSON.

Palmerton, Pa.

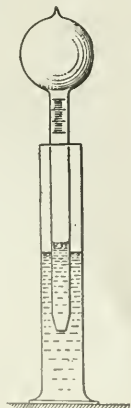


FIG. 2.  
CORRECTION  
TUBE

### Recovery of Molybdic Acid for Steel Mills

To the Editor of Chemical & Metallurgical Engineering

SIR:—I have just read the article on "Recovery of Molybdic Acid for Steel Mills" in your issue for Aug. 15, 1918. This article in all its essentials is a word-for-word copy of an article of mine published in the *Journal of Industrial and Engineering Chemistry*, vol. 7, page 213.

W. D. BROWN.

Carnegie Steel Co., Duquesne, Pa.

To the Editor of Chemical & Metallurgical Engineering

SIR:—I am very much surprised to learn that Mr. W. D. Brown of the Carnegie Steel Company had previously published the note on the "Recovery of Molybdic Acid for Steel Mills." The information which I contributed to your journal some time ago was given me by another chemist and I had no knowledge that it had ever been published or that it was a copy of another article. If this was taken from Mr. Brown's publication I wish to express an apology for seeming to publish the material as my own.

W. H. LYNAS.

Columbus, Ohio.

### Research Preparedness in the Zinc Industry

To the Editor of Chemical & Metallurgical Engineering

SIR:—The interesting letter of Mr. J. H. Hastings, commenting upon and accenting my paper in your issue of July 1, presents some views as to detail construction of retorts and charging that may be good but are not those I had in mind.

The briquetting of zinc charges appeared to have been about as well worked out by me two years ago as was desirable, but since then I have run across a process that may displace all pressing so far as roasted charges are concerned, and cut the cost of the act from one dollar per ton to perhaps 25 cents. This process will not do, however, for the lime-process briquet which I feel will be the briquet of the future, for several reasons.

Mr. Hastings makes the statement that because of using the vertical retort the maintenance charges will increase, but gives no reasons. My conclusions would be that maintenance would be less, because there would be no sagging of retort, and less slag action on vertical sides than on a horizontal bottom.

The savings that can be made in zinc distillation are indeed large, but so radical in action as to defer the attention of distillers until the electrothermic furnace using the lime process in the hands of mine owners and waterpower companies in the Northwest, makes it necessary for them to economize or go out of business.

Comments like those of Mr. Hastings show that some of us are thinking, which outside of quick dollar-making is almost a lost art.

PARKER C. CHOATE.

A tin-smelting plant has lately been erected at Leeuwpoot (Transvaal), and it is understood that operations will begin shortly.

## Western Chemical and Metallurgical Field

### Cyanide.

CANADIAN mills using cyanide are furnished their solvent by the Cassel Cyanide Company, Ltd., of Glasgow, Scotland, at a price which varies from month to month and which is based on the rates which the maker pays for the raw materials. The ruling price for the chemical to the Canadian mills during the early part of 1918 was in the neighborhood of \$0.25 per pound (plus duty) for standard cyanide titrating 100 per cent KCN, delivered to the nearest railroad station. The sodium cyanide normally supplied titrates to the equivalent of 130 per cent KCN or more, but the price to consumers is calculated on the basis of 100 per cent KCN, as noted above. In the early part of 1917 a shortage was threatened on account of a prospective labor shortage, the tendency of the military authorities in Great Britain then being to overlook all peaceful industry and sacrifice everything for the vigorous prosecution of the war. On the proper representation being made in London by the combined Canadian, South African and Australian governments, all these difficulties were removed, and now, so long as ships are available to cross the Atlantic, no further trouble need be anticipated.

In the western United States there is plenty of cyanide available on the market in the form of one-ounce eggs. Comparatively little is taken by mills, gold and silver cyanidation being on the wane, for well-known reasons. Much more is used in gas-fumigation of citrus trees. The United States supply is furnished almost exclusively by Roessler & Hasslacher Chemical Co., from their Perth Amboy plant. In the Mexican markets cyanide from both the American and Glasgow firms is being offered at reasonable prices.

### Town Planning in Copper Camps.

Some managers can readily see the advantage of retaining contented workmen after asking their account-



FIG. 1.—THE PLAZA

ant to tell them the cost of the labor turnover. Then they are almost ready to become paternalists in an effort to keep a man after they have got him. Others are more obtuse, even to requiring I. W. W. propaganda to drive home the fact that only a "floater" will inhabit an old-fashioned construction camp.

An enlightened view, in fact the only tenable view, of housing conditions has been taken by the management

of the New Cornelia Company when developing their oxide mine and leaching plant at Ajo, Arizona. Situated in the midst of an absolute desert at the southern edge of the state, the natural surroundings are as unenticing and the heat of summer as enervating as can possibly be imagined. Yet their operations, calling for the highest skill in both mining and metallurgical departments, demanded at all times a stable group of expert workmen.

An idea of how well the effort to counteract the natural unattractiveness of the surroundings has suc-



FIG. 2.—HOUSES FOR WORKMEN

ceeded may be had by the accompanying view of part of the plaza.

Water is pumped from wells many miles distant, and is therefore at a premium, yet enough can be spared for the needs of this beauty spot which forms the community center, surrounded on all sides by colonnaded walks and modern store-buildings. Neat little houses, properly designed for hot weather use, furnish the men and their families comfortable homes, but no praise is too great for the real effort displayed to relieve the terrible desert monotony with a spot which delights the eye.

The officials of the Phelps-Dodge Corporation had more to work upon at Tyrone, New Mexico, than did their competitors at Ajo, yet one has as much admiration of the way they have improved their opportunities. Their settlement is approached by a wonderful roadway over the continental divide, and is situated in attractive rolling hills, covered with scrubby trees and bushes where foliage is almost evergreen. How well their engineers have availed themselves of these advantages is seen from the picture of the Mexican houses built on Bellotal Avenue, which is merely one of the roads winding back through the little valleys converging to the plaza itself. One familiar with the squalor of the ordinary pueblo almost wonders if the Mexican appreciates such advantages as would the Western American.

### War-Profits in Metal Industries.

The Federal Trade Commission has submitted a lengthy report at the request of the Senate, giving their available information on the present range of profits in various industries. In the case of the metal industries, this information is largely gained by cost-finding by the experts in the Commission's employ.



In general, the commission declares that profiteering exists, much of it due to advantage being taken of the necessities of heavy production, but some of it to "inordinate greed and barefaced fraud." Some instances of fictitious padding of cost accounts were found, by such means as large depreciation charges, increased salaries of officials, adding interest to cost, charging new construction to repairs, placing inflated value on raw materials, and manipulation of inventories. The outstanding revelation is the heavy profit made by the low-cost concern working under a price fixed by the government to stimulate production from even the higher-cost institutions. This not only produces an economic situation fraught with hardship to the consuming public, but strengthens the dominating position of the low-cost plants.

In the case of steel, the United States Steel Corporation is cited as an instance of the fully integrated mill; its profits in terms of the total amount invested show net earnings as follows:

|            | Per Cent |
|------------|----------|
| 1912 ..... | 4.7      |
| 1913 ..... | 5.7      |
| 1914 ..... | 2.8      |
| 1915 ..... | 5.2      |
| 1916 ..... | 15.6     |
| 1917 ..... | 24.9     |

Mills which start with steel furnaces are generally very prosperous. In some cases individual mills have made objection that the government prices are too low for them to show returns on investment of from 40 to 319 per cent on the business of 1917.

Figures show that 21 copper companies, including a large proportion of the so-called "high-cost" companies, made 1917 profits of from 1 to 107 per cent, an average of 24.4 per cent, as compared to 11.7 in 1913. Probably over 70 per cent of the production is marketed at profits of over 20 per cent on the investment. There does not appear to have been any concerted action in putting up prices; the high level is attributed to the scramble among the Allied governments for the metal. In this trade, as in others, however, there is a strong tendency to increase and maintain prices against the forces of competition. For instance, custom smelters continue to hold in force deductions for the risk of carrying copper, which risk no longer exists. On the other hand, some large mining companies have long-term contracts still in force which enable them to have their ores smelted at less than present cost.

No unusual profits exist in the zinc industry, taken as a whole, except in the case of the New Jersey Zinc Company, whose position is due to the possession of an ore body of unusual richness and purity. This company published its profits for 1916 as being 72.5 per cent, and they paid dividends amounting to 76 per cent, while the Trade Commission's figures indicate a real profit of 95.9 per cent for that year.

The International Nickel Company has a natural monopoly on nickel in the United States, owing to its ownership of mines in Canada. It has maintained prices at the pre-war level, and its increased profits have been due to increased output demanded by the war. While "profiteering" in this case is not charged, the Commission questions whether the company might not have been satisfied with smaller prices and smaller profits in an essentially war material.

## Program of Fourth National Exposition of Chemical Industries

Grand Central Palace, New York

Week of Sept. 23, 1918

The addresses comprise a series of symposiums devoted to a consideration of

THE DEVELOPMENT OF CHEMICAL INDUSTRIES IN THE UNITED STATES, NOTABLY SINCE JULY, 1914.

Monday, September 23rd.

Afternoon (2:30 P.M.) Opening Addresses.

CHARLES H. HERTY, Chairman, Advisory Committee.

WM. H. NICHOLS, President, American Chemical Society.

F. J. TONE, President, American Electrochemical Society.

G. W. THOMPSON, President, American Institute of Chemical Engineers.

Evening (8 P.M.) Motion Pictures.

WATER POWER, ITS DEVELOPMENT AND USE

\*The Falls of Iguizu, Argentine; Great Latent Powers.

\*Power of Wealth—Hydraulic Development.

\*Power Transmission (4 reels).

Canadian Shawinigan Falls Power Development and Its Surrounding Chemical Industries (3 reels). (Shawinigan Water & Power Co.)

\*Fixation of Atmospheric Nitrogen at Niagara Falls and Feeding the Soil With It (2 reels). (American Cyanamid Co.)

Tuesday, September 24th.

Afternoon (2:30 P.M.) Symposium: ACIDS and CHEMICAL ENGINEERING.

E. J. PRANKE (American Cyanamid Co.), Development of Nitric Acid Manufacture.

EMERSON P. POSTE (Elyria Enameled Products Co.), Developments in the Manufacture of Glass Enameled Apparatus.

Evening (8 P.M.) Motion Pictures.

THE OIL INDUSTRIES

\*The Story of a Cake of Soap.

\*Light from the Rocks; Natural Gas (4 reels).

Lake Asphalt Industry (Barber Asphalt Co.).

Asphalt Roofing Industry (Barber Asphalt Co.).

Asphalt Colloids (Barber Asphalt Co.).

(9 P.M.) Speakers:

J. A. SWITZER (University of Tenn.), Waterpower Potentialities of East Tennessee.

HERBERT C. HENEGAR (American Zinc Co.), Mineral Resources of East Ten-

nessee. (Representing Knoxville Chamber of Commerce.)

### Wednesday, September 25th.

Afternoon (2:30 P.M.) Symposium: POTASH.

C. A. HIGGINS (Hercules Powder Co.), Recovery of Potash from Kelp.

LINN BRADLEY (Research Corporation), Recovery of Potash from Iron Blast Furnaces and Cement Kilns by Electrical Precipitation.

JOHN W. HORNSEY, Potash from Desert Lakes and Alunite.

ALFRED DE ROPP, JR. (American Trona Co.), Potash from Searles Lake.

Evening (8 P.M.) Motion Pictures.

Electrical Precipitation of Potash from Cement Dust (Research Corporation).

\*Colloid Chemistry.

The Operation of a By-Products Coke Plant (2 reels). (H. Koppers Co.)

Moving a Forest to France (4 reels). (Southern Pine Association.)

The Story of Potash—Production at Searles Lake.

### Thursday, September 26th.

Afternoon (2:30 P.M.) Meeting: AMERICAN CERAMIC SOCIETY—Chairman, L. E. Barringer.

L. E. BARRINGER—Manufacture of Electrical Porcelain (Illustrated, Motion Picture).

A. V. BLEININGER—Recent Developments in the Ceramic Industries.

H. RIES—American Clays.

F. A. WHITAKER—Manufacture of Stoneware (Illustrated, Slides).

J. B. SHAW—Fuel Conservation.

S. C. LINBARGER—Carborundum Refractories.

These will be followed by motion pictures as designated for the evening program.

Evening (8 P.M.) Motion Pictures.

#### THE CERAMIC INDUSTRIES

Glass Making (Corning Glass Co.)

†The Making of Cut Glass.

Manufacture of Electrical Porcelain (General Electric Co.).

†The Making of Pottery.

(9 P.M.) Speakers:

J. A. SWITZER (University of Tennessee), Waterpower Potentialities of East Tennessee.

HERBERT C. HENEGAR (American Zinc Co.), Mineral Resources of East Tennessee. (Representing Knoxville Chamber of Commerce.)

### Friday, September 27th.

Afternoon (2:30 P.M.) Symposium: METAL INDUSTRIES.

LEONARD WALDO (Rumford Metal Co.), Development of the Magnesium Industry.

ALCAN HIRSCH (Hirsch Laboratories), Ferro-Cerium Pyrophoric Alloys.

THEODORE SWANN (Southern Manganese Corp.), Ferro-Manganese.

JOS. W. RICHARDS (Lehigh University), Ferro Alloys of Silicon, Tungsten, Uranium, Vanadium, Molybdenum and Titanium.

Evening (8 P.M.) Motion Pictures.

CARELESSNESS: THE DESTRUCTION OF LIFE, WEALTH AND RESOURCES

Careless America (Firestone-Universal).

\*The Crime of Carelessness.

\*The Workman's Lesson.

Keep Your Business Going (3 reels). (General Fire Extinguisher Co.)

\*Vaccines for Prevention of Disease (4 reels).

### Saturday, September 28th.

Afternoon (2:30 P.M.) Symposium: INDUSTRIAL ORGANIC CHEMISTRY.

S. P. SADTLER (S. P. Sadtler & Son), Industrial Organic Chemistry and Its Progress.

C. A. HIGGINS (Hercules Powder Co.), Kelp as a Source of Organic Solvents.

GEO. H. TOMLINSON (Kinzing, Bruce & Co., Inc.), Wood as a Source of Ethyl Alcohol.

Evening (7 P.M.) Motion Pictures.

Manufacture of Zinc Oxide (New Jersey Zinc Co.).

Manufacture of Genuine Wrought Iron Pipe (3 reels). (A. M. Byers Co.)

\*From Log to Lumber (4 reels). (Southern Pine Association)

The Wonderland of the Appalachians (3 reels). (Cinchfield Railway)

From Coal Mine to Corn Field—Production and Use of Ammonium Sulphate (The Barrett Co.).

(9 P.M.) Speakers:

J. A. SWITZER (University of Tennessee), Waterpower Potentialities of East Tennessee.

HERBERT C. HENEGAR (American Zinc Co.), Mineral Resources of East Tennessee. (Representing Knoxville Chamber of Commerce.)

### Synthetic Phenol

Our attention has been directed to an error which occurred in the make-up of the article of Mr. A. G. Peterkin in our issue for September 1, 1918. The titles of Charts I and II were inadvertently reversed and should be changed in order to make the descriptions clear. Chart I represents the new process of Dennis and Bull, and Chart II the old Barrett process. If the titles are transposed the references in the text will be correct and no further confusion will follow.

\*Films so indicated are shown by courtesy of Bureau of Commercial Economics.

†Films so indicated are shown by courtesy of Ford Motor Co. Films are all single reel unless otherwise indicated.



## Colorado Meeting of the American Institute of Mining Engineers

An Account of the Technical Sessions Held at Denver and Colorado Springs—Members of the Institute Visit Mines and Metallurgical Plants at Denver, Colorado Springs, Cripple Creek, Pueblo and Leadville

THE one hundred seventeenth meeting of the American Institute of Mining Engineers, held in Colorado during the week of September 2, was the first to be held in the Centennial State for twenty-two years. The meeting was a pronounced success, worthy of Colorado engineers and comparing favorably with the Institute's Western meetings in recent years. All this was in spite of the bad weather which pursued the convention almost throughout the week, culminating on Thursday in a heavy snowstorm which almost stalled the party in its Pike's Peak automobile trip, and prevented the visit to the Golden Cycle mill.

### MONDAY, SEPTEMBER 2

The meeting opened on Monday, September 2, with a technical session on Metallurgy, held in the Brown Palace Hotel in Denver. There was a large attendance of engineers, but unfortunately very little discussion of the papers developed. In the absence of the authors, all of the contributions except that by C. A. HANSEN were read by title. The paper on Electrostatic Precipitation by O. H. ESCHHOLZ brought forth a large amount of written discussion, while so many members present asked for rather extended time in which to present their views that the chairman of the meeting, Mr. T. B. STEARNS, announced that a special session on precipitation would be held later in the week. Discussion of this paper was therefore deferred until Thursday evening at Colorado Springs, and is reported farther on.

Immediately after adjournment, the members and guests were taken to the ferro-alloy plants near Utah Junction, the equipment of which was described in a paper at the morning session by ROBERT M. KEENEY, manager of the Iron Mountain Alloy Co.

### Visit to Ferro-Alloy Plants

The plant of the Iron Mountain Alloy Co. contains one 1200-kw., three-phase furnace, and one 1800-kw., three-phase furnace, giving a total capacity of 12 long tons of ferromanganese per 24 hours. The former furnace is supplied with power by three 400-kw., single-phase transformers, having a ratio of 13,200 to 75 volts, and connected  $\Delta/\Delta$ . The voltage on the furnace is 72 volts. The 1800-kw. furnace is likewise connected to three 600-kw., single-phase transformers. The furnace shells in both cases are 18 ft. long, 8 ft. wide, 7 ft. deep, and are lined with magnesite. The electrodes on the smaller furnace are of carbon, 17 in. in diameter, and on the large furnace 24 in. in diameter. No roofs are used, and regulation of electrodes is by hand.

The plant of the Ferro Alloy Co., also at Utah Junction, contains one 750-kw., three-phase furnace, to which power is supplied by three 250-kw. transformers, connected  $\Delta/\gamma$  to give 129 volts on the furnace cables, the transformer ratio being 13,200 to 75 volts. The furnace operates with an actual voltage of 120 volts, and produces about 3 tons of ferrochrome per 24 hr. from 40 per cent  $\text{Cr}_2\text{O}_3$  ore. The furnace consists of a steel shell of circular cross-section, 8 ft. in diameter by 7 ft. deep, lined with magnesite, and having three 12-in. carbon electrodes. A 450-kw. furnace, of the same size as the 750-kw. furnace, is also operated on chrome ore. This furnace is three-phase in appearance, but operates electrically as a single-phase furnace. There are three vertical carbon electrodes 8 in. in diameter with a conducting carbon bottom. Power is supplied by three 150-kw., single-phase transformers, two of which have a ratio of 13,200 to 95 volts, and one a ratio of 13,200 to 100 volts. From each transformer, one lead goes to one vertical electrode, and one lead to the carbon bottom,



so that the transformers are electrically independent. The furnace voltage varies from 90 to 95 volts.

At intervals, 150-kw., single-phase furnaces are operated on ferrotungsten. These furnaces have one vertical graphite electrode 4 in. in diameter, with a water-cooled steel bottom-contact. The furnace shells are 4 ft. in diameter, and are mounted on trunnions, the slag being poured by tilting the furnace. All of the electrodes are regulated by hand. The chrome furnaces are operated without roofs and the tungsten furnaces with roofs.

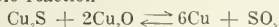
#### Tour of Mountain Parks

After the excursion to the electric-furnace plants, and luncheon at the Denver Club, came the incomparable automobile ride over Genessee Mountain through Denver's mountain parks. Many stopped en route at the pottery of the Herold Porcelain Works in Golden. This most pleasant day closed with an informal dinner at the country club.

#### Oxygen and Sulphur in the Melting of Copper Cathodes

At the morning session on metallurgical subjects, STANISLAUS SKOWRONSKI, research engineer of the Rariton Copper Works, presented two papers on the furnace refining of copper cathodes.

Discussing his first paper, the author gave the results of analyses of samples of copper taken from a refining furnace at 30-minute intervals when poling under both a coke and charcoal cover. The results are presented in graphical form and show that in the oxidation period the reversible reaction



starts toward the right immediately and is completed when the oxygen content of the charge is about 0.35 per cent. It apparently reverses when poling has brought the oxygen down to about 0.08 per cent. The sulphur in cast copper is mostly absorbed from the carbonaceous cover; therefore charcoal gives a lower-sulphur copper than does coke.

It is becoming better understood that the "surface set" on the pitch of copper is directly controlled by the sulphur and perhaps certain reducing gases, such as carbon monoxide and hydrogen, rather than by the oxygen; that sulphur raises the "set" or overpoles the copper, thus necessitating a certain amount of oxygen which therefore depresses the "set" to counterbalance the action of the sulphur.

In these two charges sampled, the "pitch" of the copper was the same, yet owing to the lower sulphur in the product melted under charcoal, its oxygen content is also much lower, affording great improvement in the quality of the copper. The refiner did not know how much sulphur was present in his final product; he simply worked the copper to the desired pitch, and the sulphur present in each charge determined the amount of oxygen necessary to give the proper "surface set" on the copper.

#### Relation of Sulphur to Overpoling of Copper

In Mr. SKOWRONSKI's second paper, the common definition of overpoling was advanced; that is "copper which has been excessively reduced during the poling period of the refining process" and so porous as to

be unfit for use. When melting very pure cathode copper in a graphite crucible under charcoal and in contact with green wood, the resulting ingots (free of sulphur and very low in oxygen) had a "level" set and proper "pitch." Overpoling is therefore thought not due to a lack of oxygen—it is apparently impossible to overpole copper by over-reduction if it does not contain sulphur and possibly other reducing gases. High-sulphur alloys were made by melting cathode chips with the addition of weighed amounts of cuprous sulphide. When melted in uncovered crucible, the oxygen tended to increase with the sulphur, thus giving in most cases no evidences of overpoling. When melted under charcoal, however, the oxygen was reduced approximately 75 per cent and the high-sulphur ingots were badly overpoled. Another study of the electrical characteristics of copper ingots showed that a low conductivity was due to oxygen rather than sulphur.

From these results, it is evident that cuprous oxide counteracts the effect of sulphur, either by increasing the solubility of sulphur in copper, or, as pointed out by Johnson, by inducing a physical condition of equilibrium between the sulphur, tending to "overpole" the copper, and the cuprous oxide, tending to "underpole" it. Yet neither theory explains the fact that when a charge of copper is "overpoled" it cannot be righted by a simple addition of cuprous oxide, but the charge must be re-worked to set copper.

"It takes a comparatively large amount of cuprous oxide to counteract a trace of sulphur; this explains why, in the refining of copper, the gases from fresh fuel will often "overpole" the copper during the casting period, and also why copper cannot be held in the furnace at the proper pitch more than a few hours. It also explains the limit of recharging cathode sheets into the furnace after the copper has been worked to the proper pitch, the sulphate present on the cathode sheets overbalancing the equilibrium established between the cuprous oxide and the sulphur."

The author concludes that both oxygen and sulphur affect the pitch of the copper, leaving open the questionable effect of hydrogen and carbon monoxide.

Discussing this paper Mr. PHILIP L. GILL pointed out the difficulty of maintaining a balance between cuprous oxide and the reducing gases when casting conditions are favorable to segregation, and he thought that many experimental results could be ascribed to the fact that copper cast in small chills set differently than in large wire-bars. He was always able to overpole copper in refining furnaces, even when melting sulphur-free cathodes with low-sulphur coal and when poling under charcoal. In such cases of overpoling a 100,000-lb. bath, the copper absorbed at least 20 pounds of something in 20 minutes, this something he thought more likely to be carbon monoxide and hydrogen from the green wood than the  $\text{SO}_2$  from the furnace gases.

#### Electrolytic Zinc

An important paper by C. A. HANSEN on this subject has already been abstracted in METALLURGICAL AND CHEMICAL ENGINEERING, May 1, 1918, Vol. 18, p. 481. Mr. J. L. VARDLEY thought that a more timely publica-

tion of such important information would have prevented the duplication of much tedious research. Also that since at the present time there are three very large plants operating on three widely different ores by processes independently and simultaneously perfected, the electrolytic production of zinc was evidently not such an abstruse problem as published information would lead one to believe.

Replying to a query, Mr. Hansen stated that he was absolutely sure that the Tainton or any other process operating at a high current density and acidity must have a substantially pure electrolyte in order to deposit zinc successfully.

### Antimony Smelting in China

CHUNG YU WANG presented notes supplementary to his book on Antimony, showing drawings and photographs of various types of furnaces in use in the different Chinese smelters, and detailed information on furnace charges and operation. The author notes that under the stimulus of the war price of \$900 (Mexican) per ton of regulus, a number of small smelters were erected so that the total capacity of 23,000 tons per year is now in existence. He presents two detailed cost sheets showing that the pre-war cost of \$63 per ton of regulus (1911) had jumped to \$180 in 1915.

"Due to the lack of capital, and of mutual coördination and coöperation among the smelters and the shortsighted policy of the directors of the different companies, there has not been any marked progress in the metallurgy of antimony in China. Obviously an important line of future progress should be in the direction of eliminating the heavy losses due to volatilization of the metal during the successive steps of treatment. If the loss could be lowered from the present 20 per cent to 10 per cent, or possibly less, an annual saving of at least \$600,000 would be effected, which would more than pay back the capital outlay for such alterations and additions to the existing plants."

Mr. Wang also advocates the substitution of a mechanical roaster for the long reverberatories now in use to oxidize the crude or rich ore, the improvement of the liquation furnaces, the adoption of gas-firing, and the installation of Cottrell plants. Discussing the use of "*couverture*," the author notes the well-known fact that the "market always demands good stars with fern-like structure on the slab of regulus before its acceptance. The appearance of such structure does not actually indicate the relative purity of the regulus, but is only the result of cooling it under the cover of a properly prepared starring mixture—in the absence of a proper English term, I shall call it by its French equivalent *couverture*—whose fusion point is lower than that of antimony, which is 620 deg. C. Of course, when the regulus contains impurities like sulphur, arsenic, lead or iron to any appreciable quantity, its surface shows it by specks, by a leaden appearance or by an ill-defined appearance of the fern-like structure. On the other hand, I have seen many a slab of regulus, with impurities above what are considered to be the limits imposed by buyers, whose stars are still bright and well-defined with all the appearance of well refined regulus. Now since the buyer demands such unnecessary adornment on the regulus,

he has to pay for it; for the costs for starring 1 ton of regulus amount to from \$10 to \$60 (Mexican), according to the market price of the antimony compound used. The proper procedure for charging any of the above mixtures is as follows: The mixed *couverture* compounds (usually antimony tioxate plus-soda or potash), are immediately charged into the reduction furnace as soon as the skimming is finished. The doors are closed and vigorous firing is maintained; as soon as it is observed that the mixture is completely melted, ladling commences. Each ladle dips into the molten metal and, in coming out, picks up a certain quantity of the molten *couverture*, which, when poured out rapidly together with the metal into a hot mold, completely covers the metal on all sides." The thickness of the solidified *couverture* varies from 1 to 2 mm. on all sides, 5 to 7 mm. on top, and varies from  $\frac{1}{3}$  to  $\frac{1}{4}$  the weight of the regulus produced. About  $\frac{1}{3}$  of the compound is lost by volatilization and by wall-fluxing; it is hammered from the slab and re-used until it becomes foul, when it is resmelted.

### Metallography of Tungsten

This subject was discussed at length in a scholarly paper by ZAY JEFFRIES. After briefly reviewing the manufacture of wrought tungsten products, the author discusses at considerable length the relation between thoria contents, temperature and grain-growth as explained by the germinative temperature laws. This subject is of importance in the manufacture and life of lamp filaments. For instance, an ingot made of very fine metallic powder welded at the minimum temperature is too fine grained, brittle and hard to be worked. By heating this ingot just above the germinative temperature the ingots are much more readily deformed. On the other hand it is desirable to keep the grain size as small as possible since the resistance to grain growth inherent in the small size gives better results in the lamp filament, for the operating temperatures in an incandescent lamp are in the grain-growth range.

"Tungsten is not an easy metal to polish. It is so resistant to the action of abrasion of the polishing powders that levigated alumina can be substituted for tripoli to advantage just preceding the rouge.

"White cast iron has been used to advantage as a mounting material for small pieces of tungsten which cannot conveniently be handled without some sort of a mounting. The piece of tungsten to be mounted is put in a mold and the molten cast iron poured around it. The white cast iron and tungsten are so nearly the same hardness that flat surfaces can be produced on the tungsten during polishing. It is sometimes very difficult to mount and polish the smallest tungsten wires. This has been accomplished in a successful manner, however, on wires less than 0.001 in. in diameter. One satisfactory method is as follows: An ordinary malleable iron  $\frac{3}{8}$ -in. (9.5-mm.) pipe cap is planed on the closed end outside. It is then drilled on the inside to a plane parallel to the outside plane. A round cover glass is put on the inside of the pipe cap, on which are placed several pieces of the small tungsten wire to be polished. Another cover glass is placed on top of these wires, after which the opening of the pipe cap is filled with powdered glass. It is then put in a furnace, being maintained in an upright

position, and heated for about 5 min. to a temperature of 800 or 900 deg. C. It has been found in many experiments that this temperature does not affect the structure of tungsten wire. The pipe cap with contents is then removed from the furnace and the glass which has congealed is pressed tightly into the pipe cap and allowed to cool slowly. The metal portion on the end of the pipe cap is then turned off in a lathe and the glass is exposed. This glass containing the samples of tungsten is polished in the ordinary manner until the tungsten wires are exposed, and the polishing is completed in the ordinary manner.

"Boiling hydrogen peroxide is used for etching most of the tungsten products. Tungsten may also be etched electrolytically with good results, using a solution of sodium hydrate for electrolyte."

Tungsten is particularly distinguished because it is brittle at room temperature when composed of small equiaxed grains, yet when of fibrous structure it is ductile and pliable. Commonly metals act exactly oppositely. Mr. Jeffries explains this phenomenon by a careful consideration of the variation in plasticity and cohesiveness of the crystalline particles and the amorphous cement binding them together. At room temperatures the somewhat malleable grains cannot deform to any considerable extent before failure occurs through the amorphous cement. In fibrous tungsten, on the other hand, the grain distortion has so arranged the boundaries that rupture is forced to take the shorter path through the more ductile grains, even though a larger absolute amount of amorphous material is then present.

Prof. C. H. FULTON, of Case School of Applied Science, presented a noteworthy paper on "The Condensation of Zinc from Its Vapor," which we will publish in full in a later issue.

#### Manufacture of Ferro-Alloys in the Electric Furnace

ROBERT M. KEENEY presented a lengthy account of the manufacture of the ferro-alloys of chromium, manganese, molybdenum, tungsten, and vanadium, giving in tabular form furnace sheets of a great many charges. This part of the contribution is so packed with information that justice cannot be rendered in an abstract, and those interested in these alloys will refer to the original.

The latter half of the paper gives the results of many experiments on ferro-uranium, the records of his failures being no less valuable than of his successes.

"Ferro-uranium was developed not because of any particular need for uranium in steel manufacture, but because of the large quantity of sodium uranate,  $\text{Na}_2\text{U}_2\text{O}_7$ , that was accumulating as a by-product of radium production. At the start, uranium exhibited one of its fundamental characteristics, its strong affinity for carbon and its tendency to form carbides. Also, in this early work it was found that no fluxing material except fluorspar could be used with sodium uranate; if either lime or silica was added, the uranium remained in the slag with practically no reduction, thus exhibiting its second characteristic, its strong affinity for oxygen."

In the attempt to make a 20 per cent uranium alloy, steel turnings were melted, and then a mixture of sodium uranate, coke and fluorspar added. It was found

that until there is 0.4 lb. of carbon in the charge for every pound of uranium very little reduction occurs. From 0.4 to 0.7 lb. carbon the percentage of uranium in the alloy varies little and the percentage of carbon in the alloy remains between 3.5 and 4.0 per cent. Both analytical and microscopic examinations indicated that when there was enough carbon present to form the double carbide,  $\text{Fe}_2\text{C}\cdot\text{U}_2\text{C}$ , the ferro-uranium held the uranium, and only then. Since the carbon in the alloy was considered excessive, decarbonization with iron scale alone and with silica was unsuccessfully attempted, for the reason that the tendency to form iron uranate results in slogging all the uranium. Melting with  $\text{U}_3\text{O}_8$  was equally a failure. Neither can ferro-uranium be made using silicon as a reducer with a commercial recovery or a low-silicon alloy.

Since satisfactory low uranium alloys were not forthcoming, attempts to produce the pure metal were made. Unsuccessful attempts resulted with sodium, carbon, aluminium and silicon in a gas furnace, but in a stationary Siemens electric furnace with magnesite walls and carbon bottom "uranium metal was reduced by carbon to a button containing over 90 per cent uranium and from 3.5 to 4 per cent carbon. The production of this low-carbon metal, with the minimum amount of carbon charged, depends entirely on manipulation of the electric furnace, a very high temperature being necessary. The product is an alloy of uranium carbide and uranium metal. The silicon and iron can be kept at about 1.5 per cent each, and the vanadium at 1.25 per cent, with the oxide used. The uranium recovery in a single operation will be from 50 to 60 per cent. The material left in the furnace is a mixture of pure oxide and carbon, which can be charged again as soon as its carbon content is determined. In this way, the ultimate recovery of uranium is high, well over 85 per cent. The power consumption is high, because pure uranium oxide is being reduced. It averages about 8 kw.-hr. per pound of metal." Two per cent carbon or more is necessary in the final product in order that all the uranium oxide be reduced, while if the button of hot sponge-metal is removed from the furnace it immediately oxidizes.

"To secure the proper temperature, the furnace must arc all the time. Regular charging is necessary. The uranium metal is allowed to form a sponge on the bottom of the furnace, which gradually builds up. Directly beneath the electrode, this sponge is pasty, but not fluid. The charge forms its own furnace lining. When a run is finished, the button of uranium metal is removed from the furnace. The unreduced residue is re-treated with another charge," giving practically complete recovery. The button contains 4.4 per cent carbon, 1.4 per cent silicon, 1.4 per cent iron, 1.3 per cent vanadium.

Given a low-carbon metal the next problem was to add it to molten steel in such a manner that its uniform incorporation would ensue. Experimenting with molten steel in an electric furnace, it was found that uranium metal was not a good addition agent because it must be in the steel bath for a considerable time to melt, while it oxidizes and slags nearly as rapidly as it becomes molten. With the experience already gained it was



now found possible to make a 50 per cent ferro-uranium with less than 5 per cent carbon by mixing steel turnings with the necessary  $U_3O_8$  and coke, together with a considerable quantity of fluorspar. The entire mixture was added slowly to the furnace at the rate of 2 pounds every 5 minutes. The resulting alloy then gave a recovery of 50 to 70 per cent when used as an addition to steel designed to contain 4 to 2 per cent uranium, respectively. Additions for low uranium steels may be made in the ladle; if considerable quantity of the alloy is to be added, however, it must be made in a skimmed furnace within one minute of pouring.

"Ferro-uranium is brittle, has a high density, and when it contains over 20 per cent uranium has a tendency to be pyrophoric, this tendency increasing with the percentage of uranium. A 3 to 5 per cent carbon alloy, with less than 15 per cent uranium, has a dense non-crystalline structure, and is dull gray in color. When the uranium content reaches 18 to 20 per cent, small bright crystals appear; and as the alloy approaches 50 per cent uranium, these crystals become larger, longer, and more distinct. From 18 per cent up, the alloy has a brilliant, flaky fracture. At 18 per cent it is hard to break, but at 50 per cent uranium it breaks easily. With the commercial 50 per cent alloy no graphitic carbon is present if the total carbon is under 5 per cent, but if there is over 5 per cent carbon, this excess carbon is usually graphitic. Any of these alloys has an entirely different appearance if cooled from a white heat in water, this treatment giving it a granular and dirty appearance. If the carbon is less than 1.5 per cent, the alloy has a dense gray appearance and is difficult to break. Under the microscope, the uranium appears to be present as the double carbide of iron and uranium,  $Fe_2C.U_2C_3$ , in a eutectic mixture of iron and carbon.

"Uranium metal with over 90 per cent uranium has a dull black color. It is dense in structure, but powders easily. It is very pyrophoric, and draws a long spark when struck across steel or another piece of uranium metal. Uranium carbide is also pyrophoric, but is more flaky in structure than a mixture of uranium metal and uranium carbide."

## TUESDAY, SEPTEMBER 3

The second day's social affairs planned for the Mining Engineers were sadly marred by wet, misty weather, which rendered impossible the many cañon trips contemplated. Most of the members attending arrived in Colorado Springs on the morning trains, and were served luncheon at the recently completed Broadmoor Hotel, where were established the permanent registration headquarters. Impressive services were held early in the afternoon in memory of the late Dr. James Douglas, brief addresses by Messrs. JENNINGS, MATHEWSON, INGALLS and O'BRIEN recounting his many sterling qualities.

Preceding the technical session were shown moving pictures of the Canadian reconstruction hospitals for wounded soldiers. The inspiring work they are there doing will point the way for us to provide adequate and honorable occupations for our own returned boys. Dr. RICHETTS then exhibited films showing the inter-

esting operations of the Ajo works of the New Cornelia Company, speaking extemporaneously in explanation of the pictures. A joint technical session on Coal and Coke was held with the Rocky Mountain Coal Mining Institute with A. E. CARLTON in the chair, while G. H. CLEVENGER presided over a simultaneous meeting on Ore Dressing and Cyanidation. The evening was enlivened by a reception and dance to visiting members and their guests.

## Technical Session

**Hand-Sorting of Mill Feed.**—A typical sorting plant on Coeur d'Alene ores handles 800 tons of ore between 12 and 4 in., from which 50 tons of shipping ore of about 45 per cent lead and 150 tons of waste is removed at a cost of \$125. Mr. R. S. HANDY, the author, believes that straight crushing and milling is not only cheaper, but is metallurgically more economical and efficient than hand-sorting followed by milling of the residue. The ore could be prepared for milling by crushing at 3 cents per ton, as compared to 16 cents in the sorting plant. The recovery on this rich fraction would be much higher than the average, since the ore does not slime and the jigs get all the coarse galena. Assuming that all the slimes passing the jigs is from this ore and would be lost it would amount to but 50 lb. of lead per day.

If there is no advantage in sorting out shipping product, there must be less advantage in sorting out waste, when the cost is 50 or 60 cents per ton of waste rejected. There is an economical advantage in milling as against hand-sorting that seems to be little considered, which is in the grading of the products. The author presents curves which show a definite economic peak where the various factors of recovery, grade and cost combine to give a maximum net money return to the operator, and concludes that "the crux of the whole matter is, 'What can you do with the hand-sorted product in the mill?' and not, 'What does the mill do on the feed it is getting?'" The only sure test is to run the mill on a hand-sorted product long enough to determine what grade of concentrate and of tailings can be achieved. I am sure a test of this kind would surprise many of the advocates of hand-sorting by demonstrating the enormous economic advantage to be gained by the opposite method of treatment. If any process in the mill produces a higher-grade concentrate than it is practicable to sort out by hand, or if any process in the mill produces a tailing equal in grade to that sorted out by hand, then it is advisable to mill the hand-sorted material."

In the discussion of this paper, Mr. A. STANLEY HILL takes issue with the author, stating that at the Hecla Company's property the ore-sorting plant does 23 per cent of the work at 15 cents per ton of material sent through, whereas it costs 36 cents to mill a ton of ore. To handle the sorted ore a heavy expenditure in mill construction would be necessary. "In the crushing plant no material is obtainable for any purpose other than milling, whereas in the sorting plant we obtain waste suitable for mine filling (an acute problem, as tailings could not be shipped from the mill except at prohibitive rates)." In order to be convincing, Mr. Handy's statement that recrushing and rejigging produces less sliming than occurs in the bed of the jig when bringing

up the grade of the concentrate should be supported by sizing tests and proper analyses.

Mr. W. L. ZEIGLER pointed out that the advantages of hand-sorting depend mainly upon the physical characteristic of the ore in question, especially of the possibility of removing extremely hard gangue, of the chance of hand-separating ore containing minerals with difficulty separated by concentration or which slimes excessively.

CLARENCE A. WRIGHT called attention to the Joplin practice, where the hoisted rock is dumped on a 4- or 5-in. grizzly. Many barren flint boulders are sorted here, the quantity reaching 20 per cent at times, the inclusion of which these operators feel would lower the capacity of the mill and increase operating costs.

Replying to the critics, the author said he thought Mr. Hill had not considered that the large proportion of his milling cost is in the handling of middlings and fine material, which products would hardly be increased by handling the coarse high-grade ore. If Mr. Hill's mill feed consisted of nothing but the material which is sorted, his lead recovery and costs would put the milling world to shame.

**Fine Grinding Plant of the Barnes-King Co.**—In a description of this plant, Mr. J. H. McCORMICK notes that the all-slime treatment was adopted in order to treat ores from several mines differing somewhat in nature. One hundred and fifty tons of ore per day are crushed in coarse breakers, and then ground in slow-speed Chilean mills. "These mills make a remarkable reduction, but leave some fine sand to be slimed in the tube-mills. Repairs are required rather frequently and access to make repairs is difficult, making the mills unpopular with the attendants. Crushing costs, however, compare favorably with other modes of coarse crushing, being, in fact, rather less than those shown by larger plants using ball-mills. An undesirable feature of these mills in a slime plant is that their product is too uniformly fine for regrinding in a pebble-mill without undue consumption of pebbles."

The balance of the paper presents a description of the flow-sheet, together with data as to the metallurgical recoveries and costs. As an instance, Table I is selected:

TABLE I—PRINCIPAL ITEMS IN COST OF MILLING 52,885 (Dry) TONS

|                                     | Total Amount<br>Used | Total<br>Cost | Per Ton   | Cost     |
|-------------------------------------|----------------------|---------------|-----------|----------|
| Lane steel                          | 21,576 lb.           | \$2,596 79    | 0 41 lb.  | \$0 0491 |
| Grinding pebbles                    | 534,000 lb.          | 5,796 85      | 10 10 lb. | 1 096    |
| Cyanide                             | 40,490 lb.           | 13,138 04     | 0 77 lb.  | 2 484    |
| Lime                                | 583,823 lb.          | 3,352 99      | 11 08 lb. | 0 634    |
| Zinc shavings                       | 44,835 lb.           | 9,010 90      | 0 85 lb.  | 1 704    |
| Steam coal                          | 489,000 lb.          | 2,167 35      | 9 25 lb.  | 0 410    |
| Borax glass                         | 4,530 lb.            | 887 09        | 0 08 lb.  | 0 168    |
| Lumber-tailings dam                 | 29,892 ft.           | 777 52        | 56 ft.    | 0 187    |
| Commercial hydrochloric acid        | 7,574 lb.            | 990 16        | 0 14 lb.  | 0 187    |
| Commercial sulphuric acid           | 17,819 lb.           | 488 46        | 0 34 lb.  | 0 092    |
| Fuel oil                            | 1,210 gal.           | 176 98        | 0 02 gal. | 0 0033   |
| Diaphragms No. 4                    | 222                  | 579 80        |           | 0 0110   |
| Crucibles No. 273                   | 23                   | 1,351 46      |           | 0 255    |
| Mint and express charges            |                      | 3,491 26      |           | 0 660    |
| Elevator bucket belt, 13-in., 7-ply |                      |               |           | 0 017    |
| Elevator buckets 12-in., 10-gal.    |                      |               |           | 0 013    |

**Effect of Oxygen on Precipitation of Metals from Cyanide Solutions.**—Mr. THOMAS B. CROWE'S paper on this subject excited much favorable comment. He became convinced that nascent hydrogen, given off by dissolving zinc, is the real precipitant of gold from cyanide solution; thus while dissolution of the metal is an oxidizing process requiring oxygen for its operation, precipitation is essentially opposite, a reducing process requiring hydrogen. In precipitating solutions

containing dissolved air much of the zinc was wasted because its evolved hydrogen had first to combine with and remove oxygen before getting an opportunity to precipitate zinc.

"Laboratory tests on the application of a vacuum to solution before the addition of zinc-dust confirmed my theory. Large tests were tried, apparatus was designed that would continuously apply a vacuum to solution during its flow to the precipitation presses, and gradually the vacuum system of precipitation worked its way into our mills, with the result that the zinc consumption has been cut in half, which fact is especially gratifying to us during the war period with its prevailing high prices.

"A thorough scrutiny of our former work revealed the fact that, for dissolution purposes on our particular ore, the cyanide solution strength was much higher than was necessary, having been kept high for the sake of good precipitation. In fact, the solution strengths in our mill had been reversed—the strongest solution was the barren; and this being used as a wash on the filters, occasioned high cyanide consumption. The high strength of the barren solution was caused by the necessity of adding lump cyanide at the head of the precipitation process to insure low-grade solutions to be used in washing.

"With the installation of our vacuum system, we found that perfect precipitation could be maintained without the addition of lump cyanide, and today our mills are running with the highest solution strength in the agitators, and not in the barren tank. This, together with a generally lower solution strength in all parts of the mill, has allowed a material reduction of cyanide consumption."

J. V. N. DORR, in commending the paper, said that in his opinion Mr. Crowe had made the greatest single improvement in the chemical end of cyaniding in the last 20 years, while Mr. G. M. TAYLOR, manager of the Victor and Independence Mills said that in these two plants the saving in zinc and cyanide, in treating 2000 tons of ore daily, amounted to \$30,000 per year. Chairman CLEVINGER said that without endeavoring to detract from Mr. Crowe's work in the least he thought the same thing had been done inadvertently in vacuum filtering in Butters' type machines for many years.

G. T. HANSEN said that in his practice he found that heating the pregnant solutions to 170 deg. F. to precipitate copper partially accomplishes deoxidation of the solutions, although at a higher cost.

**Roasting Cripple Creek Ores for Amalgamation and Cyaniding.**—A. L. BLUMFELD and J. M. TROTT described the methods used at the Golden Cycle custom mill. They bed as class A ores containing less than 2 per cent CaO, and higher lime ores, which require 50 per cent longer time in the roaster ore separately bedded as class B. The crushed ore is fed to an Edwards duplex roaster; operating details, temperatures, and mechanical features, together with the chemical reactions normally proceeding, are explained at length.

The production of soluble sulphides and sulphates must be avoided because of its action as a cyanide, and in deoxidizing the solutions. "Calcium sulphate, formed either in the roasters or by reaction of soluble sulphates in the ore on meeting the lime in solution, is decidedly

deleterious. The hot ore warms the crushing solution. This becomes saturated with calcium sulphate and precipitates as the solution cools. These crystals fill pipes, launders and Dorr thickeners, render filter mats and clarifying mats impermeable, coat Merrill filters, frames and cloths and form a deposit on the zinc and zinc boxes. In class A ores these troubles are comparatively unimportant, although considerable time is required to neutralize the solutions, whereas class B ores often require none."

While an "over-roast" will produce excellent results in a standard cyanide plant, a better residue can be obtained by a cheaper and less complete roast if the amount of soluble sulphide, total sulphur, HCl-soluble and  $\text{Na}_2\text{CO}_3$ -soluble sulphur is held under close control by chemical analysis.

"The limits of insoluble sulphur are: Class A, 0.10 per cent; class B, 0.15 per cent. The limits of soluble sulphide are: Class A, 0.10 per cent; class B, 0.15 per cent.

"Experience has shown that class B ores give good residues with higher total and insoluble sulphur and soluble sulphide, than class A. The chemical reasons for this are still obscure, but it is possible that the interaction between the sulphates and sulphides in the roasters, as noted above, gives a larger amount of each as a secondary reaction, and these then do not have so deleterious an effect in the treatment."

In order to adopt this delicate treatment certain details of the treatment subsequent to roasting were essential. Thus, blankets catch the coarse coated gold much better than do plates. The colloids must be eliminated so that the ore may be leached exceedingly fast. Otherwise a "slip-up" in one roaster will cause a rich residue by complete deoxidation of the solution. Removal of colloids is effected in a Dorr bowl classifier. A further precaution to be observed is that "change of solution must be made quickly to allow a good margin between an over-roast and an under-roast. On the sands, this is done by the back flow or wash solution in the classifiers."

Leaching tanks must be quickly filled with a semi-dewatered product in order that the sands may not rest too long in a dead solution in the early stages. Slimes must be aerated soon after classification, and more time must be given for agitation.

**Excavating Tailings at Ajo.**—Following as it did the film of the New Cornelia's operations, Mr. FRANKLIN MOELLER'S paper describing the Hewlett tailing excavator in operation at Ajo was enhanced in value. This excavator empties one of their 5000-ton leaching tanks each night. It is entirely similar in principal to the iron ore unloaders so familiar along the lower Great Lakes, with, of course, many minor modifications to fit the conditions at this plant. As Mr. E. P. MATHEWSON pointed out, the mechanical and electrical control stops which prevent the bucket from digging closer than six inches from the side walls and bottom of the tanks has resulted in an uninjured lead-lined tank which is the prime desideratum in any leaching operation.

**Grinding Resistance of Various Ores.**—A very important paper by LUTHER W. LENNOX, presented preliminary results of an investigation still under way.

"In an attempt to investigate the relative grinding resistances of a number of ores now being milled in this country and Alaska, the management of the Portland mills requested samples of average mill-run of ore from various companies. The request met with a ready response, indicating the desire of all operators to gain information on the subject." A quantity of each ore was coarse crushed and separated in various sizes, from which fractions a "standard feed" was prepared according to the following table:

| PREPARED STANDARD FEED |       |                        |
|------------------------|-------|------------------------|
| Mesb                   |       | Cum. Per Cent Retained |
| 10                     | ..... | 12 95                  |
| 14                     | ..... | 27 98                  |
| 20                     | ..... | 39 47                  |
| 28                     | ..... | 49 88                  |
| 35                     | ..... | 57 11                  |
| 48                     | ..... | 63 01                  |
| 65                     | ..... | 68 71                  |
| 100                    | ..... | 74 01                  |
| 150                    | ..... | 79 69                  |
| 200                    | ..... | 82 41                  |

One pound of this prepared ore, one pound of water, and 74  $\frac{3}{4}$ -in. steel balls were then placed in a small tube-mill, 8 x 12 $\frac{1}{2}$  in., rotated at 84 r.p.m. for a definite time, dried and screen-analysed.

"The method adopted for computing the results is that of Rittinger based on the law that work done in crushing is proportional to the surface exposed by the operation, or to the reciprocal of the diameter. For plotting the screen tests, the mesh (reciprocal of diameter) and the cumulative per cent of oversize are used as coördinates. The area between the feed and product curves will be proportional to the 'apparent work' done. The apparent work is in turn inversely proportional to the resistance of the ore to grinding; hence, the area between the curves is inversely proportional to grinding resistance.

"Unfortunately, we are unable to deal accurately with the material below 200 mesh, which is where most of the work done is represented. Microscopic measurements seem to offer the only accurate method. Curves plotted in the area below 200 mesh seem to follow no definite law, as that of a hyperbola. Many operators may feel but little interest in what happens after a certain fineness (say 48 mesh) is reached, but this does not render it necessary to measure the total work done on the whole of the ore."

The following table gives the comparative grinding resistance of various ores as determined by this method:

| Comparative Grinding Resistance | Source of the Ore                    |
|---------------------------------|--------------------------------------|
| 1.33                            | Calumet & Hecla jig tails.           |
| 1.16                            | British Columbia, Tonopah, Belmont.  |
| 1.00                            | Portland mill-feed (Development Co.) |
| 0.94                            | Smuggler Union.                      |
| 0.92                            | New Cornelia Copper Co.              |
| 0.83                            | Liberty Bell.                        |
| 0.81                            | Butte and Superior.                  |
| 0.80                            | Humboldt mine (Smuggler Union).      |
| 0.80                            | Tonopah, Belmont.                    |
| 0.79                            | Goldfield Con., ryanide feed.        |
| 0.71                            | Goldfield Con., flotation feed.      |
| 0.71                            | Alaska Treadwell, quartz & schist.   |
| 0.70                            | Miami Copper Co.                     |
| 0.69                            | Alaska Gold Mines Co.                |
| 0.63                            | Homestake, unaltered ore.            |
| 0.63                            | Arizona Copper Co.                   |
| 0.61                            | Nevada Con., pit ore.                |
| 0.53                            | Morenci, Phelps-Dodge.               |
| 0.53                            | Calumet & Arizona, roaster ore.      |
| 0.52                            | Alaska Treadwell, schist.            |
| 0.46                            | Copper Queen, mill feed.             |
| 0.38                            | Tuck Copper.                         |
| 0.37                            | Ray Consolidated.                    |

R. B. KILIANI in favorably commenting on the paper said that it would prove a god-send to those who had to "guess" at the proper grinding equipment to install



in a new mill. Given the method, the comparative grinding resistance could now readily be determined with very simple apparatus, following which definite information as to just what each type of ball-mill could be expected to do could be immediately had by referring to the performances of that grinder already operating in another mill having ore of approximately the same relative resistance.

### WEDNESDAY, SEPTEMBER 4

The party left Colorado Springs by special train for the Cripple Creek district where the day was spent at the mines and mills. In the early days of Cripple Creek the ore was mostly shipped to smelters but very soon mills were located at Colorado City and Florence. With the decreasing value of the ore, however, came the necessity of building local mills by the Independence, Portland and Vindicator companies. This has rendered possible the treatment of dumps, waste and low-grade ore reserves.

The cyanide process as now applied to the higher-grade Cripple Creek ores is briefly as follows: Coarse-crushing in rolls; roasting in Edwards, Pearce turret or Holthoff furnaces; passing the pulp over blankets for recovery of free gold; fine-grinding in tube or Chilian mills. The pulp is then treated either by straight agitation and filtration, or, after desliming, the sand is leached and the slime agitated, thickened to a suitable density, and filtered.

### Radium

The technical session held in the evening at Colorado Springs was opened by an interesting lecture on radium by Dr. RICHARD B. MOORE of the Bureau of Mines. He exhibited some of the radium products recovered by the joint efforts of the National Radium Institute and the Bureau of Mines. In the discussion Mr. W. A. SCHLESSINGER pointed out the fact that many carnotites contain soluble sulphates which precipitate dissolved radium; also that the available carnotite comes from many different localities, necessitating different treatment according to the nature of the ore. Low-grade carnotites can be concentrated, but the concentrate is so very fine and so hard to filter that it is almost impossible to extract the radium contained. Luminous paint has been largely developed within the last year, and is a mixture of the purest zinc sulphide and radium in suspension in a quick-drying varnish. About 500 milligrams per month is being consumed for this purpose alone.

### Molybdenite in Colorado

Mr. D. H. HALEY described the operations at Climax, Colorado, where low-grade deposits are being developed. Treating 0.9 per cent MoS<sub>2</sub> ore yields a recovery of 10 lb. of MoS<sub>2</sub> per ton. While the ore-dressing is still in a state of development, most of the losses are due to the presence of oxides. Promising laboratory methods for sulphidizing these have been discovered which reduce the tailings to 0.15 per cent MoS<sub>2</sub>, but the necessary reagents are not now available in quantity. At present they are increasing the capacity of the mill to 1000 tons per day, which will have an output far in excess of the whole previous world's supply.

### THURSDAY, SEPTEMBER 5

**Electrostatic Precipitation.**—On Thursday evening there was a most interesting discussion of this subject, deferred from Monday's program in Denver. Mr. DORSEY LYON was in the chair.

In the original paper of Mr. ESCHHOLZ he pointed out that the possibilities of electrostatic precipitation were known a century ago, but that its practical application awaited the perfection of the alternating-current transformer. Operating conditions require very rugged equipment because it must bear the brunt of occasional surges caused by treater breakdown, and the periodic oscillations produced at each half cycle on breaking the rectifier arc.

The problem of converting high-tension alternating current to high-tension unidirectional current has received considerable attention. Although many devices, such as mercury rectifiers, hot-cathode converters, or kenotrons, high-voltage direct-current generators, unsymmetrical electrodes, etc., have been advocated, the mechanical rectifier is still in use on practically all commercial treater circuits.

The mechanical rectifier makes a positive separation between the alternating current supplied to it and the unidirectional impulses sent to the treater, occurring when electrode separation draws the arc to the breaking point. The rectifier cannot, of course, suppress a sustained short-circuit caused by complete breakdown in the treater chambers, or by contact of electrodes. Under such conditions, it operates to limit the current until the circuit breakers open.

A delicate oscillograph shows that the voltage sustained across the treater is almost constant, its effective value reaching 97 per cent of the peak. This sustaining of the treater voltage is caused by the comparatively slow rate of treater discharge. In fact, under the usual condition of moderate clearance of gas at a velocity of 6 ft. per second, obtained in a tube 12 in. diameter, 15 ft. long, the average velocity of the dust particles, at right angles to the gas stream is, roughly but 0.8 in. per second, while complete precipitation of the same number of particles during the interval between breaking and making rectifier contact would require a velocity of 900 in. per second.

Systems depending upon the use of a mechanical rectifier for the conversion of high-tension alternating current to direct current may be classified with respect to the source of power.

A. Low-tension alternating-current generator for treater load only:

- (1) Single-phase generator supplying power to single transformer-rectifier-treater unit.
- (2) Single-phase generator supplying power to two or more transformer-rectifier-treater sets operated in parallel on the low-tension side.
- (3) Multi-phase generator supplying energy to one or more transformer-rectifier-treater sets from each phase.

B. Low-tension alternating-current industrial or lighting mains having a relatively large capacity as compared with treater demand, and supplying one or more transformer-rectifier-treater sets.

C. High-tension alternating-current main supplying energy directly to potential regulator-rectifier-treater sets.

The author strongly prefers system A-1. Other systems than those mentioned have been urged from time to time on the score of low cost, but the author points out that the advantage of low first cost is illusory since the electrical equipment costs only from 10 to 15 per cent of the cost of the treater and is only 2 to 7 per cent of the value of the yearly recovery.

In discussing the electrical features of the process Mr. FISCHER of the Research Corporation said that system A-1 is widely and correctly used in large sectionalized plants, but that system B is simplest and will become more popular. It must be installed in large-capacity circuits. Resistances are valuable because they absorb the surges. System C has never been seriously applied.

Mr. VIETS of the Research Corporation said that the transformer in system A may reflect surges like a mirror back to its closely connected generator. System B produces fewer oscillations building up dangerous electromotive forces. The treaters at Tooele were changed from system A-1 to B because the latter gives precipitation due to the increased power input which is possible, and a smoother wave form is produced. No undesirable surges are produced in the main smelter circuits. On the other hand Mr. MURPHY of Anaconda said that in the huge new plant being built, system A-1 will be used. Extensive tests were made on A-1, A-2 and B, using a seventy-five kilowatt experimental unit. System A-2 was discarded because of anticipated operating troubles. Costs of A-1 and B are practically identical. Testing showed that precipitation to be best, with most perfect wave form, which can be had with a specially designed motor-generator set and independent of fluctuations in supply-current wave form. Mr. E. P. MATHEWSON said that the following practical points should be discussed: How much humidity is necessary for good precipitation. He cited the experience of one plant where forty per cent is considered best while at Miami the treater on the ore dryers makes an excellent recovery. He also wished information regarding the effect of the nature of solids on the efficiency, saying that zinc oxide is notoriously hard to precipitate. Mr. SOCKETT of Tooele said that converter fume was treated best when sprayed, but that the formation of sulphuric acid was to be avoided. Fume is hardest to precipitate but dust is easy. Mr. RICKETTS said that Miami gets a white precipitate from its converters, recovering all the copper but passing all the zinc oxide. Mr. VIETS said that the Research Corporation's work showed that most careful humidification was necessary on zinc oxide. Mr. SOCKETT of Tooele said that the annual repair cost on the Dwight and Lloyd precipitator is 20 per cent. The net yearly recovery of fume is 38 per cent on the Dwight and Lloyd and 56 per cent on the converter precipitator.

Platinum was first discovered in South America in a section of what is now the Republic of Colombia. Although users of this metal must now depend for their supply practically entirely upon the Colombian mines, since Russian sources of supply have been temporarily abandoned, there appears to be no danger of these resources being exhausted.

## French Chemical Industry and the War

"If it were necessary to decide," said a French writer in the *Revue des Deux Mondes* of July 18, "which of all things produced by industry has been most needed and useful to the country since the war began, and without which defeat would have been rapid and inevitable, I should reply without hesitation that it is sulphuric acid."

It has long been an economic maxim, he continued, that the factor which best represents a nation's economic progress is its consumption of sulphuric acid. It is the very life blood of war industries. In the two years preceding 1914, Germany overstocked herself with 600,000 tons of pyrites to make sulphuric acid beyond her normal requirements. These figures may be drawn from her imports from Spain and they furnish an eloquent though silent answer to the attempted German excuses for that nation's great crime. Inasmuch as the war has lasted longer than was the design of the authorities at Berlin they have had recourse to Norwegian pyrites and have cut down the allotment, for the German fertilizer industry normally requires for superphosphates alone some 600,000 tons of this leading chemical product. Bitter complaint has arisen from the farmers because of this restriction in the production of fertilizers.

The reason why sulphuric acid is needed is, among other things, to make gun-cotton or nitrated wood pulp, for smokeless powder. The cotton or pulp is first treated with nitric and sulphuric acids, after which it is dissolved into a gelatine-like mass to make it insensible to shock and then it is cut into the prismatic disks which constitute smokeless powder. The proportions of nitric to sulphuric acid required to make gun-cotton are respectively one to three, although no part of the sulphuric acid is present in the final product. The purpose of the sulphuric acid is to combine with the water which is produced by the action of strong nitric acid upon the cotton or cellulose, because as soon as more than a very slight amount of water is present the reaction stops. Something must be added to take up all the water that is formed and an excess of concentrated sulphuric acid will do it, because it is one of the thirstiest bodies known to chemists. But the more it gets the less it wants, so that only a very strong acid will serve the purpose. Ordinary chamber acid such as used in the fertilizer industry will not do at all. What is really needed is oleum or fuming sulphuric acid, and to make this economically the only thing in the world that will answer is platinum.

When the war broke out the monthly production of sulphuric acid in France was only about 5,400 tons per month, mostly at the St. Gobain works, while the German production in times of peace the writer states to be 145,833 tons per month. The present French production, however, for war purposes alone has been increased to over 100,000 tons a month, somewhat approaching the present German production.

Members of the American Chemical Society have been very much interested in this substantial advance in the French manufacture in view of the daily increasing needs for sulphuric acid as the Allied army grows in numbers as well as power.

# Starting and Stability Phenomena of Ammonia-Oxidation and Similar Reactions

"Conversion Curve" and "Heat of Reaction Line"—Influence of Temperature, Catalytic Poisons, Thickness and Number of Catalytic Gauzes—Velocity and Concentration of Reacting Gases

By F. G. LILJENROTH

IF THE temperature of the gauze or catalyst of an ammonia-oxidation burner is varied, but all other conditions such as mass flow, gas composition, etc., are maintained constant, the percentage conversion or the degree of reaction will in principle vary according to the curve shown in Fig. 1. At low temperatures there will be practically no nitric oxide formed, but at a certain temperature the conversion will begin to increase very rapidly because the reaction velocity is highly dependent upon the temperature. At still higher temperatures the ammonia will begin to decompose into its elements, and the rate at which the conversion increases will be lower; or in other words, the shape of "conversion curve" will change from convex to concave and at a certain temperature, which I understand is somewhere around 750 deg. C., the conversion will reach a maximum of nearly 100 per cent. Thereafter, the conversion will again decrease and reach a zero value at a fairly high temperature.

The heat of reaction within the temperature limits in question is practically constant and equals about 53,000 gram-calories for each gram-molecule of nitric oxide formed. If we assume a 100 per cent conversion and the presence of, for instance, 9 molecules of air for each molecule of ammonia in the initial gas mixture, then the temperature rise of the gas current due to

the heat of reaction will be equal to  $\frac{0.95 \cdot 53,000}{7.4 (9 - 1)}$  or 675 deg. C., assuming 5 per cent heat-losses by radiation or convection. If the temperature of the ingoing gas is 25 deg. C., then the temperature at the gauze will be 700 deg. C. The figure 7.4 represents the average molecular heat-capacity of the gas mixture at constant pressure. As the gas mixture consists principally of diatomic gases and as the temperature range is comparatively small, it is readily seen that this quantity is practically independent both of the conversion percentage and of the temperature, and that it can with great accuracy be put equal to 7.4.

If the ammonia content in the initial gas mixture is maintained constant, the temperature rise due to the heat of reaction will increase in proportion to the conversion and the temperature of the gauze is graphically represented by the straight line in Fig. 1. This line refers to an initial gas composition of 9 to 1 and to a temperature of the ingoing gas of 25 deg. C. To any other gas composition and to any other temperature of the ingoing gas there corresponds another line. I wish to call particular attention to the fact that in order not to complicate the problem, I have deliberately disregarded the heat of reaction due to the dissociation of ammonia into its elements and other secondary reac-

tions which take place principally at the descending part of the conversion curve. Such a first approximation is permissible because the losses are in any case small.

## GENERAL CONDITIONS OF STABILITY

The straight line, which will be called the "heat of reaction line," cuts the "conversion curve" ordinarily at two points, *a* and *b*, Fig. 1. It seems, therefore, as if it would be possible to have two points of operation for any burner at a given gas composition and gas flow. But a closer investigation shows that the reaction cannot be maintained at the point *b* because the conditions for stability at this point are not fulfilled. Suppose that the burner is working at this point and that for some reason the temperature decreases by the small amount of *dt*. Then the conversion will decrease to point 1. This decrease will cause the temperature to be lowered still more, to point 2, and this will in turn

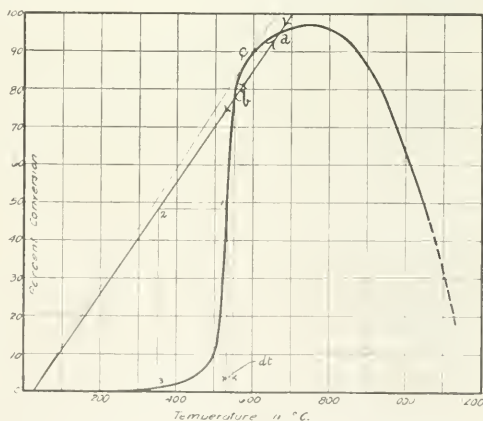


FIG. 1.—CONVERSION CURVE. VELOCITY AND CONCENTRATION OF GAS CONSTANT

cause a new decrease in the conversion, to point 3, and so on. In other words, the burner will go out.

If we assume that for some reason the temperature increases, it will in the same way be found that even in this case we will move away from the point of intersection, which is indicated in the figure by the arrows pointing apart from this point.

If we treat the other point of intersection similarly (point *a*), it will be found that conditions are just opposite. If for some reason we depart from the point, we will immediately be carried back to it, which fact is



indicated by two arrows both pointing toward the point. Point *b* is therefore an unstable location while point *a* is a stable one. As can easily be understood, this characteristic difference depends upon the manner in which the heat of reaction line cuts the conversion curve. In

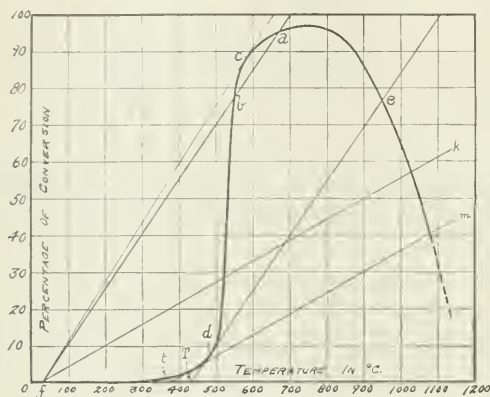


FIG. 2.—CONVERSION AT IGNITION POINT

order to obtain stability the heat of reaction line must cut the conversion curve from below, and from this it follows that the part of the conversion curve to the left of the tangential point *c* is unstable, but that the part to the right is stable. It will also be understood that the stability or instability increases with increase in the size of the angle at which the line and the curve cut each other.

#### STARTING OF THE REACTION

From what has been said regarding the instability of the point *b*, we can now understand that the ammonia-oxidation process is not self-starting or self-exciting, but that the gas, in order that the reaction may be started, must be heated by a flame or by electricity to at least such a temperature *T* that the resulting line becomes a tangent to the ascending part of the conversion curve, as is shown in Fig. 2. In such a case the reaction will start and after a short time arrive at point *e*. After this the starting flame can be removed and the reaction will move to point *a*. This not only makes it very clear whether and why the ammonia oxidation or any other continuously operated catalytic reaction is self-starting or not, but it also gives us a method by which to predetermine the temperature *T* which is necessary to start the reaction. This "ignition-temperature," as seen from Fig. 2, is always much lower than the reaction-temperature; or, in other words, it is not necessary to heat the reaction to its full temperature but only to help it overcome the obstacle formed by the ascending part of the curve. When this obstacle has been overcome, the reaction will take care of the rest itself and work up to the full temperature.

The temperature necessary to start the reaction can be decreased by using a gas mixture richer in ammonia, because the position of the heat of reaction line will be lowered. This is indicated by the lines *fk* and *tm* in Fig. 2. I understand that this method of starting is really used in some oxidation plants.

The shape of the conversion curve of all continuously operated exothermic catalytic reactions is in principle the same as that of the ammonia oxidation. It ascends at first, due to the fact that the reaction velocity increases with the temperature, but as it is limited by the always descending equilibrium curve, it must sooner or later reach a maximum; thereafter it begins to descend. (In the ammonia-oxidation process the descent begins earlier than would be expected from the equilibrium curve, this being due to the fact that another reaction, the decomposition of ammonia into its elements, begins to take place at higher temperatures beside the oxidation reaction.) The possibility that there are continuous exothermic reactions which are self-starting is therefore not excluded, because the only condition that needs to be fulfilled is the necessity of having the conversion curve from the beginning lie above the heat of reaction line.

An example of a self-starting reaction is offered by the long known fact that the hydrogen-air or hydrogen-oxygen flame can be ignited by means of a small piece of platinum sponge. This is represented in principle in Fig. 3. The lower curve corresponds to the non-catalytic reaction which, as may be noted, is not self-starting. By using a strong catalyst the curve is raised so that from room temperature and up it lies above the heat of reaction line, this being the general condition for self-excitation. The temperature of the platinum sponge will consequently increase to the point *a* which is always above the ignition temperature *T* of the non-catalytic reaction. The fact that a hydrogen flame can be ignited by means of spongy platinum induced inventors to try the same experiment with ordinary coal gas. It was found, however, that the platinum sponge began to glow but that the gas would not ignite. This

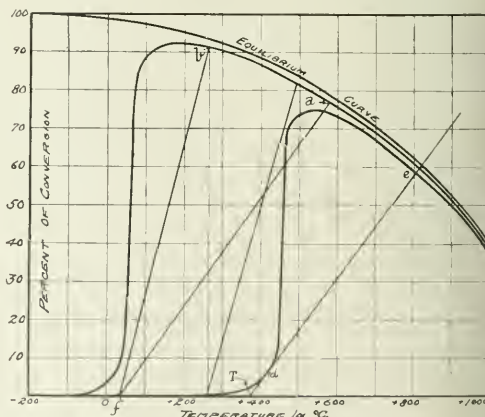


FIG. 3.—CONVERSION. SPONTANEOUS IGNITION

was explained by saying that coal gas is not so inflammable as hydrogen and that the temperature of the platinum sponge was too low.

How can this fact now be brought into agreement with our theory? The explanation is very simple. The

<sup>1</sup>As can easily be shown by Nernst's "New Theorem" that the ammonia-nitric oxide equilibrium is, within the temperature limits in question, practically constant and above 99.99 per cent. For obvious reasons this equilibrium cannot be determined experimentally.

radiation of the ignition system is very large, even if the radiation of the whole system is zero, and to the ignition-conversion curve (the upper curve) belongs, therefore, not the same heat of reaction line as to the main conversion curve, but a line much further to the left. If the point of intersection *b* between this line and the catalytic conversion curve corresponds to a lower temperature than *T*, it can be seen that the platinum sponge will begin to develop heat without being able to ignite the gas. In order to raise the temperature to *T* we can place two pieces of platinum sponge in series so that the gas arrives at the second one, preheated to such a temperature that the final temperature is higher than *T*. If it is not enough with two, we can put three pieces in series.

Numerous other arrangements have been proposed in order to ignite the coal gas flame by means of platinum sponge, and the reasons why one arrangement works better than another, or why it does not work at all, are very vaguely stated in the literature, but with this explanation become extremely clear and simple.

#### DETERMINATION OF THE CONVERSION CURVE

The heat of reaction line can be very easily determined both theoretically and experimentally, but the conversion curve can be determined only by experiments. Points on the descending part to the right of point *a* (see Fig. 2) can be determined by preheating the ingoing gas to different temperatures; at the same time we can also obtain the part of the curve which is left of point *d*. The part of the curve between *a* and *c* can be determined by increasing the heat losses, for instance by water cooling the burner. The unstable part of the curve between points *c* and *d* cannot be determined directly, but it can be determined indirectly by extending the stable parts of the curve and connecting points *c* and *d* in an intelligent way. In case the temperature, caused by the heat of reaction, is small, which for instance is the case in the Haber process (due to both the low heat of reaction and the low conversion obtained), the unstable part of the conversion curve will be very short. Practically the whole conversion curve can be determined therefore simply by cutting out the heat exchanger and heating the gas electrically, keeping a constant current or voltage.

#### PRACTICAL CONDITIONS OF STABILITY

It has been noted that the only condition which needs to be fulfilled in order to keep a reaction going, when it once has been started, is the necessity of having the heat of reaction line cut the conversion curve from below. We would expect therefore that it should be possible to work at the maximum point of the conversion curve because this point is on the right side of point *c* where the stability zone begins (Fig. 2). This also is possible under ideal conditions, that is, if gas composition, gas flow etc. are maintained absolutely constant. In practice, however, there will always be small variations in gas composition and gas velocity which cause the heat of reaction line and the conversion curve to change their positions continuously. If, for instance, the ammonia content in the ingoing gas for some reason decreases, the heat of reaction line will turn counterclockwise around its point *f* on the abscissa. If it turns past the tangential position *c* and remains there long

enough for the gauze to cool below the ignition temperature, the burner will go out. This time, which by the way can be calculated exactly if the conversion curve is known, is very short because the gauze is rapidly cooled by the incoming cold gas mixture, the heat capacity of the gauze and the walls being comparatively small.

The conversion curve is also affected by the gas composition and besides that by the gas velocity. As already noted, both of these quantities vary in practice a few per cent and consequently the heat of reaction line and the conversion curve will both oscillate around an average position. Ample margin between points *a* and *c* must therefore be provided. If the top of the conversion curve is sharp, it will be impossible to work at a maximum efficiency, because we have to move the working point further to the right side, sacrificing efficiency in order to obtain stability. This also implies higher temperature. If the conversion curve is very flat, which seems to be the case in the ammonia-oxidation reaction, it will be possible to work not only at the top point but even a little to the left of it. As far as I understand, this is really what is done in the ammonia-oxidation process if no heat exchanger nor any additional heat above the heat of reaction is used. A decrease in the radiation losses will consequently improve not only the stability but also the efficiency. If the radiation is decreased as much as possible, and if we are still on the ascending part of the conversion curve, the only way to reach the top is to use a heat exchanger or some additional heat. If we are very near the top it will probably not pay to go into this complication.

The margin of stability must be greater, the greater the variations in initial gas strength and gas velocity. It is therefore of importance to keep the motors at a constant speed driving the ammonia and air-blowers and in general to keep the gas current as steady as possible. Of how great importance this is can be determined only if conversion curves of a number of different gas compositions and different gas velocities are known.

#### INFLUENCE OF CATALYTIC POISONS UPON STABILITY

If occasionally the steadily flowing gas current should carry along some foreign gas, we would have the same kind of disturbance as we would if the ammonia content varied. If the foreign gas or matter is not indifferent, or if it acts as a poison to the catalyst, the disturbances may be still worse. In such cases still more margin must be provided; that is, we must work further to the right of the maximum point (see Fig. 4) which means a higher temperature and a decrease in the conversion from point *a* to, for instance, point *g*. We must now remember that the conversion curves always refer to absolutely pure gas mixtures and we will have therefore in addition to this decrease another reduction depending upon the frequency, the nature, and the duration of the impurities.

This can be stated also in another way. In a plant where such impurities are likely to appear, we must safeguard ourselves against the burner going out by working with more ample margin; that is, even if for some length of time the gas happens to be pure, we will still have a lower efficiency than in a plant where we

know the gas mixture to be constantly pure. When the impurities appear, however, we will have an additional loss, but the loss cannot, of course, be precalculated but only estimated from practical experience.

The first kind of loss can be measured exactly by running the burner with pure ammonia at the same gas flow and gas strength as when the impure ammonia is used. It can also be determined from the conversion

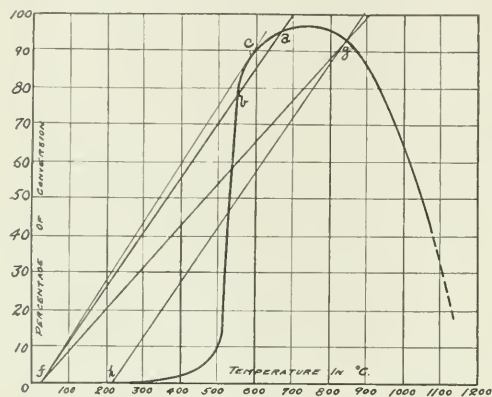


FIG. 4.—CONVERSION. CATALYTIC POISONS

curve in the following way: Suppose the gauze is heated by electrical energy but that no heat exchanger is used, and furthermore that the electrical power consumed is equal to 0.03 kw.-yr. per ton of  $\text{HNO}_3$  which equals  $\frac{0.03 \times 8760 \times 3600}{4.2}$  kg. cal. per ton of  $\text{HNO}_3$ ,

which in turn equals  $\frac{0.03 \times 8760 \times 3600}{4.2} \times \frac{63}{1000}$  or 14,000 kg. cal. per kg. mol. of  $\text{NH}_3$ .

The temperature rise due to the electrical heating alone will hence be  $\frac{14,000}{7.4(9+1)}$  or 190 deg. C. If this temperature is added to the plain heat of reaction line, we get a line (*hg*, Fig. 4) beginning at  $190 + 25$  deg. C., and ending at  $700 + 190$  deg. C. This line cuts the conversion curve at point *g* and we can thus find the conversion and the loss. The temperature rise of 190 deg. C., due to the electrical heating, could also have been determined experimentally by running the burner with a normal gas flow and a normal electrical energy but without igniting the burner. This test can be run just as well with ordinary air as with ammonia-air mixture, thereby saving the ammonia.

In the ammonia-oxidation process it happens that if the radiation losses are small, the reaction itself develops just about enough heat to give the proper temperature, or in other words, the heat of reaction line cuts the best conversion curve in the neighborhood of the top just far enough to the right of the point *c* to secure stability, assuming that pure raw materials (for instance, high-grade coke-oven aqua ammonia) are used. In case the ammonia contains impurities, poisonous to the catalyst, as seems to be the case with cyanamide-ammonia, higher temperatures must be employed in order to secure stability, as has been shown above. This can be done either by using a heat exchanger, line *fg* (Fig. 4), or by supplying some additional heat, line *hg* (Fig.

4). As there is always a time lag in the action of any heat exchanger the temperature will not decrease instantaneously as the impurities come along. If, therefore, the impurities are of short duration with fairly long intervals, the use of a heat exchanger may be preferable to the plain heat of reaction method, assuming that it could be employed here. If, on the other hand, the impurity periods are long and the intervals short, it will be understood that the heat exchanger is inferior to the plain heat of reaction method.

This is a true analogy to the action of a flywheel in connection, for instance, with a rolling mill. In a blooming mill very heavy flywheels are used, whereas in a wire mill the rotating masses must be made as small as possible. The employment of additional heat, either by preheating the gases in a fuel-heated furnace or by electrically heating the gauze, gives the most stable conditions, especially if the external heat alone gives a temperature which is higher than the ignition temperature, in which case the burner ignites itself again as soon as the impurities have passed, supposing that these were of such magnitude so as to cause the burner to go out. It is not very probable that this is the case in any ammonia burner because it would mean unnecessarily high stability, very high temperature and very low efficiency. On the contrary, even electrically or fuel-heated burners must be ignited by a flame or coil or by increasing the current in the gauze above the normal value.

In regard to fuel heating versus direct electrical heating of the gauze, we would expect one method to be just as good as the other, assuming that the electric current has no direct activating influence on the platinum.

Such an influence is very improbable in view of the excellent results obtained without the use of electric heating; this has probably been adhered to as an easy way of explaining the fact that the direct electric heating gives higher stability than if the same amount of additional heat is supplied outside the gauze. The following explanation seems to me much more plausible. The electrical resistance of platinum as well as of other metals increases with the temperature. At 700 deg. C. it is about 3 to 4 times as high as at 0 deg. If, therefore, due to a weakening of the gas strength or to poisonous impurities, the gauze begins to cool and blacken, the current flowing through it will immediately increase in the same proportion as the resistance decreases. Furthermore, as the heat developed is proportional to the square of the current times the resistance ( $I^2R$ ), it follows that the electric energy converted into heat will increase when the temperature decreases. This phenomenon is the more marked, the less external electric resistance there is connected in series with the gauze. If the external resistance is equal to or higher than the internal, the reverse condition will prevail and it may be necessary to use a costly automatic constant current regulator. If none or only a very small amount of external resistance is used, it is not only useless but detrimental to use automatic regulation. Further investigation of this problem leads to very interesting conclusions in regard to the manufacture of the gauze and the arrangement of the electrical heating and starting. Besides this "electrical influence," the electric heating has the advantage of having the heat supplied directly within the metal,



whereas with outside heating the heat must first travel from the gas to the metal.

It has been noted that when using even pure raw materials ample margin of stability must be provided to take care of the oscillations in the heat of reaction line and in the conversion curve, because of variations in the gas strength and gas velocity. We will discuss this matter more in detail.

INFLUENCE OF GAS VELOCITY

The gas velocity has no influence upon the heat of reaction line but affects the conversion curve in the following manner: At low temperatures, where practically no ammonia dissociation takes place, the conversion is higher the lower the gas velocity, because the time of reaction is longer and the reaction consequently comes closer to equilibrium. At higher temperatures this increase is probably more than counterbalanced by the increase in ammonia dissociation due to the same conditions as the increase in the ammonia oxidation. If, therefore, the velocity corresponding to our working curve is called 100 per cent, the curves corresponding to 90 per cent and 110 per cent will probably have the positions and shapes indicated in Fig. 5.

It can be easily seen why the stability decreases when the gas velocity increases and why the flame can be "blown out." If the velocity decreases, the stability will at first increase, but probably decrease later on. If this were not the case, it would be possible to get the reaction to start without the use of an ignition flame simply by increasing the gas velocity very slowly from zero up.

As seen, I have shown the 110 per cent curve having a higher peak than the 100 per cent curve. If this really is the case, there is a double reason why we should increase the working velocity and at the same time increase the temperature by, for instance, introducing a

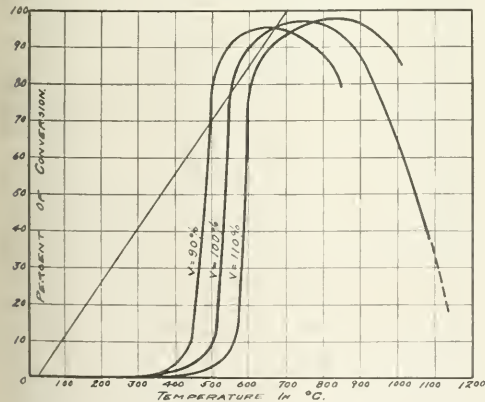


FIG. 5.—VARIATION OF CONVERSION WITH VELOCITY

heat exchanger. The output of the plant will increase not only in proportion to the gas velocity but also in proportion to the conversion. If we increase only the gas velocity without changing the heat of reaction line the conversion will go down, probably more rapidly than the velocity will go up, resulting in a lower output instead of a higher one. Besides this the stability will rapidly decrease, as already noted.

INFLUENCE OF GAS STRENGTH

The influence of the variations in the ammonia content of the gas mixture upon the stability is more complicated because such variations influence both the heat of reaction line and the conversion curve. This first influence is very simple; the heat of reaction temperature at a certain conversion increases in proportion to

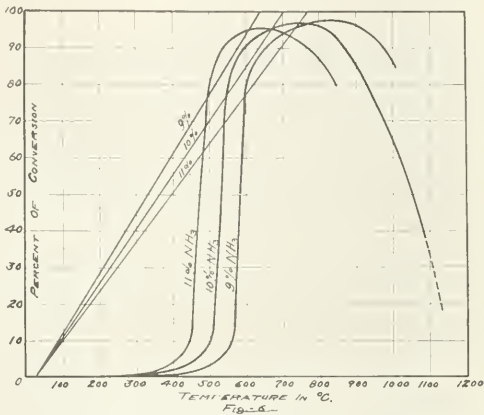


FIG. 6.—VARIATION OF CONVERSION WITH CONCENTRATION

the ammonia content (see Fig. 6). The latter influence, however, is very complicated and the only guess I would like to make is that at lower temperatures the conversion increases with the gas strength. If the curves for different gas strengths appear as is indicated in Fig. 6, we can understand that the stability will be greatly increased if the gas strength increases, because the heat of reaction line moves to the right and the conversion curve to the left. Conversely, the stability will rapidly decrease when the gas strength is weakened.

What has been said regarding the possibility of improving the process by decreasing the time of reaction and by introducing at the same time a heat exchanger can also be applied here if we substitute gas strength for time of reaction and assume that the conversion curve in principle moves as indicated in Fig. 6.

If the curve, on the contrary, moves to the right instead of to the left when the gas strength increases, the stability will be practically unaffected by changes in the gas strength, because the heat of reaction line will oscillate synchronously with the conversion curve.

OXYGEN INSTEAD OF AIR

If the ammonia gas is mixed with oxygen instead of with air we must for economical reasons work with a very high ammonia content in the ingoing gas. The heat of reaction line will consequently turn clockwise a very big angle, giving a temperature several times higher than that when using air at the same conversion. If the conversion curve has the shape assumed and if this shape is not materially changed by the exclusion of the nitrogen, the result will be a higher temperature and stability, but a lower efficiency than if air were used. This can, of course, be corrected by water-cooling the gauze, but as when using air, the stability

is sufficient and the efficiency above 95 per cent, the use of oxygen is not justified, at least not for the sake of a possible increase of efficiency.

#### THICKNESS AND NUMBER OF GAUZE

In view of what has been said, the influence of the thickness and number of gauzes becomes very simple and clear.

The thickness of the gauze affects the conditions only in the matter of reaction time, assuming that the effective contact surface is changing in the same proportion as the contact time. A change of the thickness of the gauze, therefore, acts in the same way as a change in the gas flow. The result will be the same whether we double the gas flow, or decrease the thickness of the gauze to one-half. If the gas flow and the thickness of the gauze are both increased or both decreased in the same proportion, the conditions will not be changed at all.

The influence of the number of gauzes is the same as the influence of the thickness of the gauze, but only if the gauzes are placed very near each other and in good metallic connection so that the temperature is always the same in all the gauzes.

The problem is quite different and much more complicated if the thermal interconnection of the gauzes is incomplete. In order not to make the problem too complicated, I will assume the extreme condition that the gauzes are completely independent of each other thermally. This means that no other heat exchange can take place between the gauzes than by the way of the gas current. Let us assume that we have a burner working with, for instance, two gauzes, placed in complete contact with each other. If, now, the two gauzes are moved apart and thermally isolated from each other so that no heat can be radiated or conducted between them, the first gauze will act as if the velocity had been increased to double its value. If, before moving the gauzes apart, we were working in the neighborhood of the top of the conversion curve, the burner would probably go out, or at least work with less margin of stability. If the latter is the case, the temperature will change somewhat, but the efficiency will still be in the neighborhood of its maximum value, leaving practically nothing for the second gauze to do. If the burner goes out we have to use a heat exchanger or apply electric heating, or we have to decrease the gas flow in order to re-establish the stability. If we apply any of these means just sufficiently to get the same stability and efficiency as before, there will again be practically no work left to the second gauze. But even if we use these means in excess, or in other words, when we work far down on the descending part of the conversion curve, the second gauze will have very little to do because the losses in the first gauze are principally caused by ammonia decomposition. Only in case we work far down on the ascending part of the conversion curve would there be some ammonia left for the second gauze, but as previously shown, the ascending part of the conversion curve is practically all within the unstable zone. If this could in some way be made stable, the gas leaving the first gauze would have to be water-cooled before it entered the second gauze in order to prevent the latter from reaching too high a temperature and too low a yield.

In case platinum should become very scarce, such an arrangement might be advantageously used, in that a cheap low-grade catalyst could be substituted for the first gauze and the succeeding platinum gauze made to do the final work analogous to the method frequently used in the catalytic-sulphuric-acid process. But the first stage of the conversion must be worked in such a way that the greater losses will consist principally of

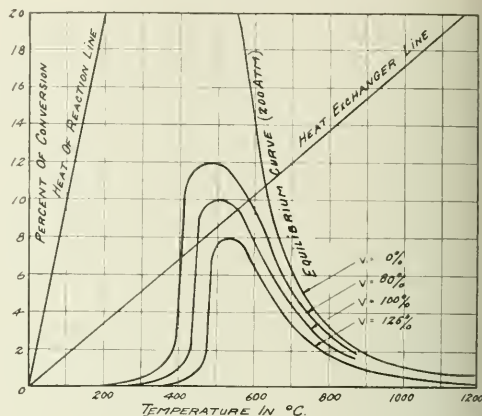


FIG. 7.—VARIATION OF CONVERSION WITH LOW GAS VELOCITIES

ammonia going unchanged through the catalyst; that is, we must work in the unstable zone, which might not be absolutely impossible.

#### SYNTHETIC-AMMONIA PROCESS

Here the conditions are still simpler because no disturbing reactions take place. The conversion curve has the same shape as in the ammonia-oxidation process. It first rises rapidly, reaches a maximum, and then begins to decrease because the conversion is limited by the falling equilibrium curve. If the gas velocity is decreased, the entire curve moves upward, and vice versa if the velocity is increased (see Fig. 7).

If seems, therefore, as if we ought to work with a very low gas velocity. This would be true if the conversion were the deciding factor, but because of the fact that the gas mixture is recirculated, the conversion is of only secondary importance. The deciding factor is the output, which is the product of gas velocity and conversion. The working point is therefore the top of the conversion curve at which this product is at a maximum. If, however, proper consideration is given to the cost of the ammonia removal and to the cost of the electric power, a new curve somewhat above this curve is obtained. Anyhow, we will assume that the curve marked velocity = 100 per cent is the most economical curve.

The heat of reaction is equal to about 14,500 g. cal. per g. mol. of ammonia at the temperatures in question. For each per cent of conversion, the corresponding temperature rise is thus equal to  $\frac{14,500}{7.25 \times 2 \times 100}$  or about 10 deg. C.

The corresponding heat of reaction line never cuts the conversion curve, which means that in the synthetic-

ammonia process, contrary to what is the case in the ammonia-oxidation process, a heat exchanger must always be used. Besides the heat exchanger, there must usually be supplied some additional (frequently electric) heat. The reason for this is that the heat of reaction is as a rule insufficient to cover the radiation loss and to create the temperature difference which is needed to keep the size of the heat exchanger within reasonable limits. If a high pressure and a good catalyst are used, the conversion will be higher, the heat of reaction will be sufficient, and no electric or other heat needs to be supplied from without except during the starting period, as can be seen from Fig. 7. The amount of electric power necessary for starting can easily be calculated if the conversion curve and the gas velocity are known. This power can be decreased if the gas velocity is lowered during the starting period, as seen from Fig. 7. It can also be noted that if the gas velocity is increased, the stability will decrease and vice versa. Ample margin of stability, therefore, must be provided; if the gas velocity is increased too much, the flame can be "blown out."

If no electric heat is used, the influence of the gas velocity on the heat of reaction line ought to be very small, because at the high mass flow per square foot here prevalent, the heat transfer (B.t.u. per sq.ft. per hour) of the heat exchanger walls is practically proportional to the gas velocity. The heat transfer is equal to the sum of two quantities, one of which is constant and the other proportional to the mass flow per square foot. If the mass flow per square foot is very large, as is the case here due to the high compression (100 to 200 atm. pressure) the constant quantity is negligible. If, after all, there is an influence depending upon a faulty design of the heat exchanger, this influence works to turn the heat of reaction line counter-clockwise when the velocity increases. As shown above, the conversion curve moves in the opposite direction. In such a case a still greater margin must be provided.

If electric heating is used but no heat exchanger, the resulting line is parallel to the heat of reaction line proper, and if a heat exchanger<sup>2</sup> but no electric heating is used the resulting line goes through the origin. Consequently, if both electric heating and a heat converter are used simultaneously, the resulting line is the sum of these two factors. If the gas velocity increases, the constant part of the temperature corresponding to the electric power decreases inversely as the gas velocity. Strange as it may sound, the reaction is therefore more sensitive for increases in gas velocity with electric heating than with only a heat exchanger.

The gas composition has no influence at all upon the heat of reaction line and practically no influence upon the conversion curve, which can be understood from the following. The conversion corresponding to equilibrium is approximately proportional to  $\sqrt{N \cdot H}$ , where H is the volume of hydrogen and N the volume of nitrogen present in a certain amount, say four volumes, of the mixture. If we are far from the point of equilibrium, the decomposition velocity is negligible and the conversion is consequently in proportion to  $H \cdot N$ . The follow-

ing tabulation shows that both  $H^2 \times N$  and  $\sqrt{H^2 \times N}$  are practically constants within wide limits:

| H   | N   | $H^2 \times N$ | $\sqrt{H^2 \times N}$ |
|-----|-----|----------------|-----------------------|
| 3.2 | 0.8 | 26.3           | 5.14                  |
| 3.1 | 0.9 | 26.8           | 5.17                  |
| 3.0 | 1.0 | 27.0           | 5.2                   |
| 2.9 | 1.1 | 26.8           | 5.17                  |
| 2.8 | 1.2 | 26.3           | 5.14                  |

The gas composition, therefore, has practically no influence upon the stability.

### CONCLUSION

In the same manner, many interesting conclusions can be drawn in regard to the starting and stability of other continuously working catalytic and exothermic reactions as, for instance, the sulphuric-acid process, the conversion of  $\text{CO} + \text{H}_2\text{O}$  to  $\text{CO}_2 + \text{H}_2$ , the conversion of  $\text{NO}$  to  $\text{NO}_2$  etc.

The method can probably be advantageously applied also to non-catalytic, exothermic, continuous or discontinuous (explosive) reactions, although the conditions here are much more complicated because the time of reaction in the first case is not an arbitrary constant but a function of the temperature, the gas velocity, the radiation etc. In the second case, the time of reaction is in itself an independent variable in addition to the independent variable which we already have, namely, the temperature.

It would be beyond the scope of this article to go into these questions, but I hope that the above examples have been sufficient to demonstrate the usefulness of the method of investigation set forth. It not only explains in a very simple manner the starting and stability phenomena and the influence of catalytic poisons on the stability, but it might also be useful for the further studying and improving of ammonia oxidation and similar processes. It is therefore desirable that pure raw material conversion curves be determined for different gas strengths and gas velocities, both for ammonia-air and ammonia-oxygen mixtures. If such curves were available, it would be possible to adjust or design a burner for a maximum commercial efficiency, giving proper consideration to conversion efficiency, output etc. This applies also to other processes.

Finally, I wish to point out that this article refers only to the method of investigation and not to any specific data. The shape of the curves and the figures given should be considered only as examples.

Washington, D. C.

### Treatment of Caustic Soda Burns

As the workmen in the kettle room of the caustic soda works are exposed to painful burns at the syphon line faucet while filling the drums as well as in handling the containers of the molten caustic, some emergency aid should be immediately available for treatments. Mr. M. Firsinger read a paper before the National Safety Convention at New York, in which he recommended a two per cent solution of acetic acid as an acid wash, followed by an oil dressing. Absorbent cotton should not be placed in immediate contact with the wound, but can be used on top of a lint-free pad saturated with vaseline, carron oil or other air excluder. Perhaps aluminium acetate would be a preferable form of neutralizer—especially in cases involving the eyes and lips. Aluminium soap would also be preferable to the lime water emulsions.

<sup>2</sup>A closer investigation shows that the most economical heat exchanger has such a high mass flow that the constant term is negligible.



# Slag Control in the Iron Blast-Furnace by Means of Slag Viscosity Tables

Application to Blast Furnace Operation of Viscosity Data Obtained in Former Investigation by Bureau of Mines—Method of Using Slag Viscosity Tables—Examples Demonstrating Their Application

BY ALEX L. FEILD

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THERE has not been available until recently experimental data which were of any great assistance to the blast-furnace operator in his control of slag composition. The Bureau of Mines has completed an extensive investigation of the properties of slags at high temperatures over a wide range of compositions. The results of this work have been published as Bureau of Mines *Technical Papers* 157, 187, and 189, and also in several technical journals.<sup>1</sup>

By means of the viscosity data obtained in the investigation it is possible to decide upon the proper slag composition by a procedure which has as its basis a series of experimental measurements conducted with care and with due regard to the needs of the case.

*Technical Paper* 187, "Slag Viscosity Tables for Blast-Furnace Work," contains the complete slag tables and is written particularly for iron metallurgists. *Technical Paper* 157, "A Method for Measuring the Viscosity of Blast-Furnace Slag at High Temperatures," was the first preliminary report and contains a description of the apparatus and methods of measurement, together with viscosity measurements on a limited number of slags.<sup>2</sup> *Technical Paper* 189, "Temperature-Viscosity Relations in the Ternary System  $\text{CaO-Al}_2\text{O}_3\text{-SiO}_2$ ," contains the more scientific results of the investigation and in addition a description of the improvements made in experimental technique since the appearance of the preliminary paper.

## PURPOSE OF THE PRESENT PAPER

In former publications, purporting to be nothing more than a permanent record of experimental measurements, it was advisable to give only a few brief suggestions as to the actual application of the data to blast-furnace operation.

It is the purpose of the present paper to indicate in some detail the most obvious method of using the slag viscosity tables in slag control, and by actual illustrative examples to demonstrate the method. It is not considered necessary to reproduce the slag tables since the publication in which they appear can be readily obtained by any one desiring it.

Beforehand, it may be well to make clear exactly what significance is attached to the term "viscosity" and to point out how this property in the case of a slag is of primary importance in determining the economy

of operation of the blast-furnace. This last matter is of unusual importance at the present time. Whether or not there will be sufficient coke at the blast-furnaces during the winter of 1918-1919 is a matter of grave importance, but the most immediate duty of every blast-furnace superintendent is to make a maximum production of pig-iron with a minimum fuel consumption.

## VISCOSITY

All bodies may be divided into three classes—gaseous, liquid and solid. For our present purpose we will confine our attention to the solid and liquid states of matter. Here we will take our stand with the physicist rather than the chemist, and simply define a liquid as any substance other than a gas, which if left to itself will assume in the course of time the shape of a vessel in which it is placed; and a solid as a body which retains its own shape under the action of small forces. According to this definition a piece of slag at room temperature is a solid regardless of whether it is glassy, or "lean," or whether it is crystalline, or "limey." On the other hand, a slag is a liquid, whether the entire mass is homogeneous or contains numerous small crystals scattered through its interior, provided it will move, however slowly, along an inclined runner under the action of gravity. In all these cases, the chemist makes a number of distinctions in his definitions, well-suited for his own needs but of no value in the present case.

Having fixed in mind exactly what is meant by "solid" and "liquid," let us give our attention to the definition of viscosity. The viscosity of any substance is proportional directly to the force required to rotate a cylindrical rod of given dimensions with unit angular velocity when immersed in the liquid. As every one knows it takes a greater effort or force to twist a pole around in a barrel of pitch than it does in a barrel of water. If it takes a thousand times as much force in the former case than in the latter, the viscosity of the pitch would be a thousand times as great as that of water. In the absolute or C.G.S. system of units used in the slag tables (*Technical Paper* 187) it so happens that the viscosity of water at 20 deg. C. is almost exactly 0.01. Hence the viscosity of the pitch would be equal to 1000  $\times$  0.01, or 10 C.G.S. units.

Another way to visualize the property of viscosity is to recall that the length of time it takes a liquid of given volume to flow through a small capillary tube, under a constant pressure-head, is directly proportional to its viscosity.

While all liquids have a definite viscosity which can be measured, the viscosity of a solid is, of course, in-

<sup>1</sup>Bulletin A. I. M. E., Feb. 1917, pp. 307-32; Dec. 1917, pp. 2030-36; 2037-45.

<sup>2</sup>Transactions Faraday Society, vol. 13, Pt. I, pp. 1-33 (1917).

<sup>3</sup>Chemical News, vol. 117, pp. 13-16, 27-29, 40-41, 54-56, 64-67 (1918).

<sup>4</sup>See also above.

finite. We may therefore define, a solid as a body the viscosity of which is infinite, and a liquid as a body, other than a gas, the viscosity of which is finite or measurable.

I have found that there exists in the minds of some a strange confusion regarding the meaning of viscosity. This is probably due to the ordinary meaning of the word "viscous" as used in conversation. Such a one is certain that molasses is "viscous" and has "viscosity"; but is at a loss when asked to compare it with water or ice, and may conclude that neither ice nor water have any viscosity. As has been stated, the viscosity of water at 20 deg. C. is equal to 0.01, while the viscosity of ice is infinitely great, i.e. greater than any value which we could assign to it.<sup>2</sup>

Just as the reciprocal of density is specific volume, so the reciprocal of viscosity is "fluidity." In other words, fluidity, as physically defined, is numerically equal to 1 divided by the viscosity. Accordingly, the fluidity of water at 20 deg. C. is  $\frac{1}{0.01}$  or 100; while the fluidity of the pitch would be  $\frac{1}{\infty}$ , or 0.1. It is obvious that the fluidity of a solid is equal to  $\frac{1}{\infty}$ , or zero. Just as there are no bodies with zero viscosity, so there are no bodies with infinite fluidity. Values expressed in terms of fluidity instead of viscosity offer certain advantages when plotted against temperature, forming very nearly a straight line function. However, it would appear that viscosity is actually the measurable property of a body, and for this and other reasons it was used exclusively in the slag tables.

#### CHANGE OF VISCOSITY WITH TEMPERATURE

The viscosity of practically all bodies decreases with rising temperature, and this rule is true without exception in the case of silicates and mixtures of silicates. The rate of change is most rapid just at the melting point. Above the melting point, i.e., the temperature at which the slag passes from the solid to the liquid state, some slags decrease in viscosity much more rapidly than others. The rate of change of viscosity at any given temperature is known as the temperature coefficient of viscosity. If we plot the temperature of the slag as abscissae and the viscosity as ordinates, we get in the case of a slag such a curve as is shown in Fig. 1, known as a temperature-viscosity curve. The line AB which the upper portion of the curve approaches asymptotically cuts the X-axis at a point corresponding to the melting point of the slag, since at that temperature the viscosity becomes infinite.

Even at temperatures well above the melting point the change of viscosity of practically all bodies is much greater than is ordinarily supposed. For instance, water just above the freezing point is about 3 times as viscous as water at 100 deg., the rate of change being about as rapid above 50 deg. as below it.

#### DEPENDENCE OF TEMPERATURE-VISCOSITY RELATIONS ON SLAG COMPOSITION

It will be sufficient here to state that the shape and position of the temperature-viscosity curve with respect to the axes is entirely dependent on the chemical composition of the slag as shown by analysis. Sometimes

a relatively minor change in the percentage of one or more of the major constituents—lime, alumina and silica—causes a great change in the temperature-viscosity relations as shown by the temperature-viscosity curve. This is due to the existence of undissociated molecular compounds of lime, alumina and silica in the molten state,<sup>4</sup> with fields of stability which are those indicated by the temperature-concentration diagram of this ternary system as given by Rankin and Wright.<sup>5</sup> If, for instance, we gradually increase the lime content of a slag the temperature-viscosity relations do not undergo a continuous, gradual change in the same direction, but display well-marked maxima and minima.

Contrary to the usual belief, changes in the percentages of the minor constituents of a slag—MgO, MnO,

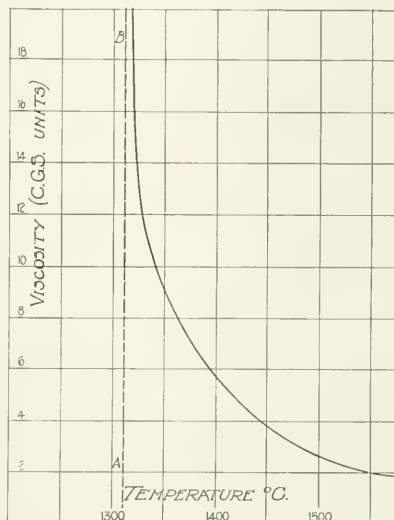


FIG. 1.—VARIATIONS OF VISCOSITY WITH TEMPERATURE

FeO, TiO<sub>2</sub>, Na<sub>2</sub>O and K<sub>2</sub>O—have a practically negligible effect on the temperature-viscosity relations provided the percentages of the major constituents—CaO, Al<sub>2</sub>O<sub>3</sub>, and SiO<sub>2</sub>—do not change relatively to one another. In the slag investigations it was found that the temperature-viscosity relations of all slags in which the sum of the percentages of the minor constituents did not exceed 14 per cent were determined only by the relative percentages of lime, alumina and silica. This condition is met by practically all slags in which the percentage of MgO, the most important minor constituent, does not exceed about 8 per cent.

Sulphur in iron blast-furnace slags is present as calcium sulphide, CaS, and should be treated simply as one of the minor constituents. In slag analysis, sulphur should be reported as calcium sulphide, CaS.

The small effect exerted by the minor constituents on the slag properties is due to the fact that they are present in the slag in the state of solution, retaining

<sup>2</sup>For the evidence pointing to the existence of silicate compounds in the liquid state, see *Technical Paper 189*, pp. 7-10, 21-23, 29-33.

<sup>4</sup>G. A. Rankin and E. E. Wright: "Ternary System CaO-Al<sub>2</sub>O<sub>3</sub>-SiO<sub>2</sub>," *American Journal of Science*, ser. 4, vol. 33, pp. 1-75 (1916); see also *Technical Paper 189*, p. 6, Fig. 1, where the essential features of the diagram are reproduced.

<sup>5</sup>For convenience in presentation the case of plastic solids, flow under shears greater than a critical value, etc., are not taken into consideration. For further information on these points see Bureau of Mines *Technical Paper 189*, pp. 10-12.

their oxide or sulphide structure. On the other hand, lime, alumina and silica are not present in the molten slag as a mutual solution of the oxides of calcium, aluminium and silicon, but as more or less complex silicates and aluminosilicates of lime. The identity and relative proportions of these silicates and aluminosilicates which are present in a slag can be readily calculated from the ternary diagram of Rankin and Wright, although, as has been previously pointed out, these investigators were not aware at that time that their data were applicable at temperatures above the saturation temperature of the melt. The presence of the minor constituents does not make itself felt appreciably until the concentration of one of them becomes great enough to result in the introduction of a new molecular species into the ternary system, changing it thereby to a quaternary system.

#### BEHAVIOR OF THE SLAG IN THE FURNACE

The blast-furnace is a furnace which operates on a regenerative principle, the highly heated gases of combustion passing up through the descending charge and pre-heating it. These gases of combustion, or flue-gases, are further used to pre-heat the air supplied for combustion, since they are high in carbon monoxide and fortunately have a fairly good calorific value.

The conditions are therefore such that if the furnace shaft were filled with coke alone the temperature would within a short while reach such a high value that the entire refractory lining of the furnace would be fused. However, if the coke is mixed with just the proper amount of material—the slag ingredients—which melts, say, at 1470 deg. and runs down into the hearth and thence through the iron notch to the outside, there will result a slow downward movement of the charge with the coke burning away at the same rate that the slag (and also molten iron) runs down into the hearth. This downward movement of the charge, initially at atmospheric temperature, is the factor which prevents the attainment of extreme temperatures in the smelting zone. It is seen then that the temperature-viscosity relations of the slag (which includes the phenomenon of melting) determines the working temperature of the blast-furnace. Like all industrial furnaces, the blast-furnace consumes an amount of fuel which increases rapidly as the furnace temperature is raised. It is upon this point that the importance of slag control as related to fuel economy hinges, and for this reason the slag problem is essentially a fuel problem.

The ternary eutectic of lowest melting point in the lime-alumina-silica system is point 2 in Rankin and Wright's diagram, having a melting point of 1165 deg. C., as determined by viscosity measurements,\* and corresponding to a composition 23.25 per cent CaO, 14.75 per cent  $Al_2O_3$ , and 62 per cent  $SiO_2$ . Therefore, as soon as a temperature of 1165 deg. C. is reached by the charge during its descent downward toward the hearth, a certain amount of this low-melting eutectic may be formed. However—and this is an important point—since this eutectic differs widely in its composition from that of the slag ingredients as a whole, and since it has with its high silica content an extremely high viscosity at all furnace temperatures, it is very probable that no formation of liquid slag sufficient to cause any appreci-

able downward movement of the slag occurs until a temperature is reached corresponding approximately to the melting point of the entire slag ingredients. At least, until there is available some experimental data on this subject, the above assumption is the simplest one that can be made.

Since with this assumption the melting point of a slag is equal to either point 5 or point 6 of Rankin and Wright's diagram, slag formation actually begins in the furnace at a temperature of either 1310 deg. C. or 1265 deg. C., these being the melting points respectively of these two ternary eutectics. The composition of point 5 is 38 per cent CaO, 20 per cent  $Al_2O_3$ , and 42 per cent  $SiO_2$ ; and of point 6 is 47.2 per cent CaO, 11.8 per cent  $Al_2O_3$ , and 41 per cent  $SiO_2$ .

When, after melting, the slag has its temperature raised to such a point as to flow around and entrap within it the molten iron globules, its metallurgical function in the blast-furnace may be said to have become operative. It is very probable that this initiation of its function as a desulphurizer and source of silicon corresponds more or less closely to a definite value of viscosity, placed tentatively at 10. It is doubtless preferable to assume that, instead of the molten slag flowing around the molten iron globules at the time when the viscosity of the former reaches a value of 10, the molten iron globules fall by gravity from a higher level into the viscous slag at a somewhat lower zone in the shaft and are imbedded therein or trapped therein by the motion of the molten slag. At any rate, the initiation of the desulphurizing process begins when intimate contact is made between iron globules and molten slag, whether the slag entraps the globules *in situ* or after the latter have moved a certain distance down the shaft.

On the other hand, measurements made on slags at flush indicate that the slag as it flows from the cinder notch has on an average a viscosity of 4.

We are concerned then chiefly with the temperature relations of the slag as it decreases from a viscosity of 10 to a viscosity of 4. This temperature interval, during which the important chemical reactions of silica reduction and desulphurization occur, may be appropriately termed the "active range" of the slag.

For the purpose of conserving coke, it should be the aim of the superintendent to keep this active range of the slag as low on the temperature scale as possible. If we leave out of consideration the black "scouring" slags containing a large percentage of iron oxide usually accompanied by undue irregularities in charge descent, it does not seem probable that in a furnace producing basic iron the operator can choose a slag having too low an active range. High sulphur in pig-iron is usually caused not by the fact that this range is too low, but that the range is too narrow, affording no flexibility and allowing insufficient time for the iron globules to be in intimate contact with the slag.

As will be shown later it is possible, having given an ore or ore mixture to determine with the aid of slag viscosity tables that slag composition which will have the lowest practicable active range.

In using the tables, there are certain precautions which must be observed by the operator.

Since, for reasons advanced above, the minor constituents are not to be given consideration, it is necessary first to calculate all slag analyses to a basis of 100 per

\*See Technical Paper 189, p. 26. The melting point as determined by Rankin and Wright, using the crystallographic method of quenched melts, is 1170 deg. C.  $\pm$  5 deg.



cent lime, alumina, and silica. In this way, all possible slag compositions can be expressed in terms of the three constituents of the ternary system  $\text{CaO-Al}_2\text{O}_3\text{-SiO}_2$ . The temperature-viscosity relations of all slags is simply a function of two independent variables, alumina and lime, or alumina and silica, or lime and silica. Obviously, the percentage of the third constituent is fixed as soon as the percentages of the first two constituents are known. This arithmetical calculation must be made whenever a slag is to be referred to the slag viscosity tables, so that it will be advisable to indicate the necessary procedure.

Let us consider a slag which shows the following analysis:

|                               | Per Cent |
|-------------------------------|----------|
| CaO.....                      | 40.17    |
| $\text{Al}_2\text{O}_3$ ..... | 13.07    |
| $\text{SiO}_2$ .....          | 35.32    |
| MgO.....                      | 5.51     |
| CaS.....                      | 3.87     |
| Other oxides.....             | 2.06     |
|                               | 100.00   |

This particular slag represents average practice in the United States, according to analyses representing 44 per cent of the blast-furnace tonnage.

The calculation is as follows: The percentages of CaO,  $\text{Al}_2\text{O}_3$ , and  $\text{SiO}_2$  are added together, making a total of 88.56 per cent. The percentages of these three constituents are then multiplied each in turn by the factor

$$\frac{100}{88.56}$$

This gives as the composition of the slag: 45.36 per cent CaO, 14.76  $\text{Al}_2\text{O}_3$ , and 39.88  $\text{SiO}_2$ , a total of 100 per cent.

The operator who is in the habit of associating certain slag characteristics to a slag containing 12 per cent  $\text{Al}_2\text{O}_3$  and 36 per cent  $\text{SiO}_2$  by actual chemical analysis, must carefully avoid comparing such a slag with one of 12 per cent  $\text{Al}_2\text{O}_3$  and 36 per cent  $\text{SiO}_2$  as given in the tables without first recalculating the slag to a basis of 100 per cent lime, alumina, and silica. After this recalculation it is probable that this slag will be represented in the tables by a 13 per cent  $\text{Al}_2\text{O}_3$ , 39 per cent  $\text{SiO}_2$  slag.

While it may seem that emphasis on such a simple matter is unnecessary, it is just such minor points as this which will make the application of the tables appear at all unusual to an operator schooled to think only in terms of percentages by analysis without regard to the relative proportions of CaO,  $\text{Al}_2\text{O}_3$ , and  $\text{SiO}_2$ . Fortunately, this is a difficulty which is not serious.

As was explained in some detail in Bureau of Mines *Technical Paper 187*, the matter of obtaining a representative sample of slag at flush for chemical analysis is a difficult problem. A single sample will in no case give the correct average slag composition, and in some cases not even approximately so. Three samples, taken at the beginning, middle and end of each flush and a sample of the slag at cast will, when made into a well-mixed composite sample, yield a fairly good representative sample. The writer has several times witnessed a spirited discussion between a blast-furnace superintendent and a works manager over a supposed change in slag composition, amounting to several per cent  $\text{SiO}_2$ , which discussion resulted in a change in the charge, when two samples taken during the same flush showed more than 2 per cent difference in their  $\text{SiO}_2$  content. The best method of combating this operating difficulty is obviously to take as frequent slag samples as can be handled by the analytical staff at the works, and if the results obtained in this way justify a further increase

in the number of samples, to increase the number of analysts.

Mention has also been made of the errors which are often found in works analyses of slags, due to the common practice of dissolving the sample in hydrochloric acid, instead of analyzing according to the accurate method of fusion with sodium carbonate. The error introduced by the former method is greater in the case of slags high in alumina than in low alumina slags, although even a moderate alumina content may cause serious difficulty. This source of inaccuracy should be given careful consideration by every blast-furnace chemist, and corrected where found to be prevalent. In most cases, lime, CaO, is not determined as such in the analysis of the slag, but is obtained "by difference," and includes other oxides such as  $\text{Na}_2\text{O}$ ,  $\text{K}_2\text{O}$ ,  $\text{TiO}_2$ , and sometimes MgO and MnO where these two oxides are not separately determined. In addition, this expedient, used for the sake of saving time, throws the sum of all the analytical errors into the CaO percentage where, more than anywhere else, an accurate value is required on account of the fact that the slag properties are peculiarly susceptible to small changes in the lime content.

The operator must therefore at the outset eliminate the above-mentioned difficulties of slag sampling and analysis, or at least reduce them to a minimum, before he is in a position to derive the greatest benefit from the application of the slag tables.

#### THE SLAG VISCOSITY TABLES

In Bureau of Mines *Technical Paper 187* are given the complete slag tables, showing the viscosity in C.G.S. units of iron blast-furnace slags for even percentages of alumina between 7 and 24 per cent; over a wide lime-silica range; for temperatures of 1350 deg. C. (2462 deg. F.), 1400 deg. C. (2552 deg. F.), 1450 deg. C. (2642 deg. F.), 1500 deg. C. (2732 deg. F.), 1550 deg. C. (2822 deg. F.), and 1600 deg. C. (2912 deg. F.); and also the temperatures at which the different slags have viscosities of 2, 4, 6, 8, 10, and 12 C.G.S. units.

The tables cover a definite portion of the ternary system  $\text{CaO-Al}_2\text{O}_3\text{-SiO}_2$ , being confined to the stability fields of calcium metasilicate and gehlenite (see *Technical Paper 187*). This particular portion of the ternary system was selected after examination of the relative proportions of lime, alumina, and silica in a number of slags representing widely different practices.

The range of slag composition included in the tables is as follows:

#### RANGE OF COMPOSITION INCLUDED IN SLAG VISCOSITY TABLES (Calculated to Basis of 100 per cent CaO, $\text{Al}_2\text{O}_3$ , $\text{SiO}_2$ )

| $\text{Al}_2\text{O}_3$<br>Per Cent | $\text{SiO}_2$<br>Per Cent | CaO<br>Per Cent | $\text{Al}_2\text{O}_3$<br>Per Cent | $\text{SiO}_2$<br>Per Cent | CaO<br>Per Cent |
|-------------------------------------|----------------------------|-----------------|-------------------------------------|----------------------------|-----------------|
| 7                                   | 50-43                      | 43-50           | 16                                  | 48-35                      | 36-49           |
| 8                                   | 50-43                      | 42-49           | 17                                  | 47-33                      | 36-50           |
| 9                                   | 49-42                      | 42-49           | 18                                  | 46-32                      | 36-50           |
| 10                                  | 49-42                      | 41-48           | 19                                  | 45-31                      | 36-50           |
| 11                                  | 49-42                      | 40-47           | 20                                  | 42-30                      | 28-50           |
| 12                                  | 49-40                      | 39-48           | 21                                  | 42-29                      | 37-50           |
| 13                                  | 49-39                      | 38-48           | 22                                  | 40-28                      | 38-50           |
| 14                                  | 48-37                      | 38-48           | 23                                  | 38-28                      | 39-49           |
| 15                                  | 48-36                      | 37-49           | 24                                  | 39-28                      | 37-48           |

It is true that a small number of furnaces are run on a dolomitic or high magnesia flux, in which cases the percentage of MgO in the slag will be well above 8 per cent, which is the upper limit fixed for the direct application of the viscosity data given in the tables. The relative importance, however, of this practice has not

yet seemed sufficient to warrant a systematic investigation of the quaternary system  $\text{CaO-MgO-Al}_2\text{O}_3\text{-SiO}_2$ . This problem will doubtless be solved, nevertheless, in the not distant future. Since the practicability of smelting to advantage titaniferous iron ores unusually high in  $\text{TiO}_2$  has been demonstrated by Auguste Rossi, it is probable that the quaternary system  $\text{CaO-Al}_2\text{O}_3\text{-TiO}_2\text{-SiO}_2$  will also ultimately demand attention at the hands of investigators.

#### SLAG CONTROL

With a given supply of raw materials—ores, coke, and limestone—the attainable economy in coke consumption is, for a specified grade of iron, chiefly dependent upon the maintenance of a proper slag composition. In the discussion of furnace operation which follows it has been convenient for the sake of brevity to assume that the reader is familiar with the salient features of pig-iron manufacture as given in the various text-books. In even a cursory study of this important industrial process it becomes evident to most readers interested in the subject that the question of the choice of slag composition has hitherto been entirely arbitrary on the part of the superintendent. In his decision he has been guided by previous furnace records and by his own experience. Nevertheless, he is called upon almost daily to meet unusual operating problems where his course of action is the combined result of intuition and shrewd conjecture. In the majority of cases such action involves a change in slag composition due to altering the composition of the charge, increasing or decreasing the burden, or both. The blast-furnace superintendent's task is at best a difficult one, and it becomes increasingly complex when furnace operations are interrupted or made irregular by such contingencies as a shortage of coke or other raw materials.

It is common in text-books to see a chapter on slags open with such a statement as, "It is required to make a slag of the following composition: 50 per cent  $\text{CaO}$ , 15 per cent  $\text{Al}_2\text{O}_3$ , and 35 per cent  $\text{SiO}_2$ ." There are certain inherent objections to such a statement. The most cogent is that the purpose of a blast-furnace is not to produce a slag of a definite composition, but on the contrary to produce iron of a definite grade, and what is more to the point, from a limited selection of ores. Probably no possible combination of his ores would enable an operator to attain a slag of such a composition as that "required" above. His problem is to utilize the ores on hand to the best advantage regardless of his personal or acquired slag preferences and with a minimum coke consumption.

#### ILLUSTRATIVE EXAMPLES TAKEN FROM PRACTICE

It is the chief purpose of this paper to point out (1) how an operator can determine what change in his charge should be made when an undesirable slag is being produced, and (2) how he can decide with the help of the slag tables, what is the "desired" slag corresponding to any given ore or ore mix, limestone, and coke. Both of these conditions can be arrived at by a purely mechanical procedure in which the personal equation of the operator is reduced to a minimum importance. A few examples taken from practice may illustrate the use of the slag tables.

The slag is making off-grade iron, high in sulphur, is chilling the furnace, i.e., running with difficulty from

the cinder notch. The slag shows by analysis the following composition:

|                               | Per Cent |
|-------------------------------|----------|
| $\text{CaO}$ .....            | 42.51    |
| $\text{Al}_2\text{O}_3$ ..... | 13.28    |
| $\text{SiO}_2$ .....          | 32.77    |
| $\text{CaS}$ .....            | 4.02     |
| $\text{MnO}$ .....            | 5.50     |
| $\text{MnO}$ .....            | 1.20     |

Re-calculating to a basis of 100 per cent lime, alumina, and silica we find the relative proportions of these oxides are:

|                               | Per Cent |
|-------------------------------|----------|
| $\text{CaO}$ .....            | 48.00    |
| $\text{Al}_2\text{O}_3$ ..... | 15.00    |
| $\text{SiO}_2$ .....          | 37.00    |
| Total .....                   | 100.00   |

Referring to the slag tables, we see that the temperature-viscosity relations of this slag and those of the compositions immediately around it clearly indicate the presence of too much  $\text{CaO}$ . These values, taken from the tables, are given below in Table I.

TABLE I.

| $\text{Al}_2\text{O}_3 = 15$ Per Cent<br>Per Cent | $\text{CaO}$ | Active Range<br>Temperature at Which |                           | Width of<br>Active<br>Range<br>Deg. C. |
|---------------------------------------------------|--------------|--------------------------------------|---------------------------|----------------------------------------|
|                                                   |              | Viscosity = 4<br>Deg. C.             | Viscosity = 10<br>Deg. C. |                                        |
| $\text{SiO}_2$                                    |              |                                      |                           |                                        |
| 40                                                | 45           | 1,453                                | 1,346                     | 107                                    |
| 39                                                | 46           | 1,470                                | 1,366                     | 104                                    |
| 38                                                | 47           | 1,525                                | 1,394                     | 131                                    |
| 37                                                | 48           | 1,594                                | 1,448                     | 146                                    |
| 36                                                | 49           | > 1,640a                             | 1,568                     |                                        |

a The symbol > signifies "greater than."

An examination of Table I shows that, while the width of the active range is sufficient, the slag demands an abnormally high furnace temperature in order to flow easily from the cinder notch, i.e., 1594 deg. C., and also that a slight increase in lime, due to many of the unavoidable irregularities in the charge would give a slag ( $\text{CaO} = 49$ ,  $\text{SiO}_2 = 36$ ) which is much too refractory, for satisfactory operation.

It is a well-known fact that extremely high-sulphur irons are most often met with in basic practice where a high percentage of lime is present in the charge. When any unavoidable fall in blast temperature occurs or when the descent of the charge is irregular or delayed, portions of the descending limey slag pass over quickly to the solid state, capable of acting chemically upon the pig iron very slowly if at all, in so far as desulphurization is concerned. In other words, the melting point of the slag lies dangerously near the temperature of the smelting zone. To maintain a furnace temperature sufficiently high to avoid this difficulty would call for an unreasonably high coke consumption and a short life of furnace lining. There appears to be considerable evidence that in basic practice many furnacemen entail an unnecessarily high coke consumption simply because they make use of a very limey slag where a less limey slag would produce an iron as low in sulphur and with the proper silicon content at a lower furnace temperature.

In the case above, the lime content of the slag (referred to 100 per cent lime + alumina + silica) could advantageously be lowered from 48 to 45 per cent. If any further difficulty was experienced due to a too hot or a too cold furnace, it could be ascribed logically to excessive or insufficient coke, and the necessary change made in the burden.

This illustrates in a general way how the tables may be used in helping to solve a slag problem which, unless successfully solved, might mean a shut-down.

It would be both interesting and profitable for the superintendent who has access to past furnace records

of pig and slag analysis and coke consumption to compare the conclusions drawn from data given in Table I for a number of slags with the actual results obtained. Unfortunately, in a large percentage of cases this is not feasible since the analysis of the slag does not include a determination of CaO as such, but only "lime" by difference.

Turning now from the case of the operator who is confronting the problem of avoiding a shut-down or continued off-grade iron due to improper slag composition, let us give our attention to the question of the initial decision as to the proper charge composition. This can be reached very conveniently by means of the slag tables, without making use of any rules-of-thumb or other maxims the applicability of which may be doubtful.

We will examine the most desirable slag practice using a mixture of equal parts of soft and semi-hard Tennessee ores, having the following composition:

|                                | Per Cent |
|--------------------------------|----------|
| Fe                             | 42.8     |
| SiO <sub>2</sub>               | 24.3     |
| Al <sub>2</sub> O <sub>3</sub> | 3.8      |
| CaO                            | 2.1      |

The coke contains 5 per cent SiO<sub>2</sub> and 3 per cent Al<sub>2</sub>O<sub>3</sub>. Let us assume a basic iron product containing 1 per cent Si and 94 per cent Fe.

Each pound of ore yields  $\frac{0.428}{0.94}$  or 0.455 pounds of pig iron. For 1 pound of pig iron produced it is necessary to flux  $1 \times \frac{0.243}{0.455}$  or 0.534 pound of SiO<sub>2</sub> and  $1 \times \frac{0.038}{0.455}$  or 0.083 pound of Al<sub>2</sub>O<sub>3</sub>. To these amounts, assuming a fuel consumption of 2240 pounds of coke per ton of pig iron, must be added, respectively, 0.05 pound SiO<sub>2</sub> and 0.03 pound Al<sub>2</sub>O<sub>3</sub>, making a total of 0.584 pound SiO<sub>2</sub> and 0.113 pound Al<sub>2</sub>O<sub>3</sub> per pound of pig iron. Since the pig iron contains 1 per cent Si, equivalent to 0.021 pound SiO<sub>2</sub> per pound of pig iron, this amount must be deducted from the available SiO<sub>2</sub>, leaving a balance of 0.563 pound SiO<sub>2</sub> per pound of pig iron.

Assuming that we charge pure limestone (100 per cent CaCO<sub>3</sub>) or a stone which contains no alumina or silica, and that the burden ratio was not changed, the ratio of silica to alumina in the slag would be equal to  $\frac{0.563}{0.113}$  or 4.98, regardless of how much limestone is charged. Taking this ratio for the present as constant and equal to 4.98, it is possible to calculate directly the possible slag compositions corresponding to varying amounts of limestone charged.

Let  $x$  = per cent of CaO  
 $y$  = per cent of SiO<sub>2</sub>  
 $z$  = per cent of Al<sub>2</sub>O<sub>3</sub>

$$\text{Then } y/z = 4.98 \quad (1)$$

$$x + y + z = 100 \quad (2)$$

Assuming that the proper slag will contain between 38 and 50 per cent CaO, we first substitute the value 38 for  $x$  in equation (2).

$$\text{Then } y + z = 100 - 38 = 62 \quad (3)$$

$$\text{From (1) } y = 4.98 z \quad (4)$$

Substituting (4) in (3), we have

$$5.98 z = 62$$

$$\text{or } z = 10.3 \text{ per cent Al}_2\text{O}_3.$$

Hence,

$$y = 100 - (38 + 10.3) = 51.7 \text{ per cent SiO}_2.$$

Repeating this calculation for the remaining percentages of CaO between 38 and 50 per cent, we obtain the set of composition shown in Table II. There is also given opposite these compositions the temperatures at which these slags attain a viscosity of 4 and 10, indicating the position of the active range, obtained by referring to the slag tables.

TABLE II.

| Percentage Composition |                                |                  | Active Range—<br>Viscosity = 4 Viscosity = 10 |         | Width of                |
|------------------------|--------------------------------|------------------|-----------------------------------------------|---------|-------------------------|
| CaO                    | Al <sub>2</sub> O <sub>3</sub> | SiO <sub>2</sub> | Deg. C.                                       | Deg. C. | Active Range<br>Deg. C. |
| 38                     | 10.3                           | 51.7             |                                               |         |                         |
| 39                     | 10.2                           | 50.8             |                                               |         | —                       |
| 40                     | 10.0                           | 50.0             |                                               |         | —                       |
| 41                     | 9.8                            | 49.2             | 1,588                                         | 1,414   | 174                     |
| 42                     | 9.7                            | 48.3             | 1,544                                         | 1,396   | 148                     |
| 43                     | 9.5                            | 47.5             | 1,509                                         | 1,382   | 127                     |
| 44                     | 9.3                            | 46.7             | 1,490                                         | 1,369   | 121                     |
| 45                     | 9.2                            | 45.8             | 1,471                                         | 1,357   | 114                     |
| 46                     | 9.0                            | 45.0             | 1,452                                         | 1,345   | 107                     |
| 47                     | 8.8                            | 44.2             | 1,443                                         | 1,320   | 123                     |
| 48                     | 8.7                            | 43.3             | 1,423                                         | (a)     | 113                     |
| 49                     | 8.5                            | 42.5             | 1,392                                         | (a)     | 82                      |
| 50                     | 8.3                            | 41.7             |                                               |         | —                       |

(a) Solidifies at 1310 deg. C.

As is obvious the calculation of the compositions given in Table II can be performed graphically with great ease after the composition of the first and last members of the series is known, since the various percentages are all linear functions of one another.

An examination of the temperature-viscosity relations of the possible slag compositions as shown in Table I does not disclose any pronounced minimum active range, nor is the active range raised by increasing lime, at least up to 49 per cent CaO, but on the other hand it is lowered thereby.

Regarding the possible temperature-viscosity relations of those compositions not in the tables, it can safely be said that a slag containing a higher percentage of lime than is given in the tables is unsuitable for proper and economical furnace operation. Such a slag lies in the stability field of calcium orthosilicate, and has a melting point which increases with astonishing rapidity with increasing lime. Probably "liming up" of a furnace is usually due to the presence of such a slag whose composition lies in the orthosilicate stability field (see Fig. 1, Bureau of Mines *Technical Paper* 189). It may be concluded then that although the active range of the slags shown in Table II is lowered by increasing lime up to 49 per cent CaO, any further increase in lime will produce a slag of unusually high melting point and therefore undesirable. From the table it is also seen that for 49 per cent CaO the width of the active range has been considerably reduced, and that for both 48 and 49 per cent CaO the slag is characterized by that peculiar property, found only in low alumina slags, of solidifying sharply from a fairly fluid melt.<sup>7</sup> It is, of course, desirable to get away from such a condition, so that the operator in choosing his slag will select a somewhat less "limey" slag, say with 44 per cent CaO, 9.3 per cent Al<sub>2</sub>O<sub>3</sub>, and 46.7 per cent SiO<sub>2</sub> having a viscosity of 4 at 1490 deg. C. and a viscosity of 10 at 1369 deg. C.

Suppose the limestone showed from analysis the following: 48.50 per cent CaO, 3.25 per cent SiO<sub>2</sub>, and 1.20 per cent Al<sub>2</sub>O<sub>3</sub>.

It has been shown above that the amount of available SiO<sub>2</sub> in ore and coke which must be fluxed is equal to 0.563 pound per pound of pig iron, and of Al<sub>2</sub>O<sub>3</sub> is

<sup>7</sup>See Bureau of Mines *Technical Paper* 189, pp. 27-28.



0.113 pound. Since we have decided to use a slag having 44 per cent of CaO (on a basis of 100 per cent lime, alumina, and silica), it is obvious that the weight of CaO which must be charged per pound of pig iron is equal to  $(0.563 + 0.113) \times \frac{44}{56}$  or 0.53 pound. But the CaO present in the ore, amounting to 2.1 per cent will yield  $\frac{0.021}{0.455}$  or 0.04 pound of CaO per pound of pig iron.

The amount of CaO to be charged as limestone is then equal to  $0.53 + 0.035 - 0.04 = 0.525$  pound per pound of pig iron, which amounts to  $\frac{0.525}{0.485}$  or 1.08 pound of limestone per pound of pig. In the preceding calculation, the value 0.035 represents the number of pounds of lime per pound of pig which must be charged to combine with the sulphur of the charge to form calcium sulphide, CaS. This is based on an assumed percentage of 3.8 CaS in the slag.

It is of interest now to calculate what effect the failure to consider the silica and alumina in the limestone had in so far as their effect on the silica-alumina ratio was concerned. The amount of silica in the limestone per pound of pig is  $0.53 \times 0.0325$  or 0.017 pound, increasing the available SiO<sub>2</sub> from 0.563 to 0.580; while the amount of alumina is  $0.53 \times 0.012$  or 0.006 pound, increasing the alumina from 0.113 to 0.119. The revised

silica-alumina ratio is then  $\frac{0.580}{0.119}$  or 4.87, instead of 4.98. This difference may, in this case, be neglected for practical purposes in deciding upon the proper slag composition. Its effect on the lime charged, however, has been taken into account.

It may possibly be advisable when using a limestone unusually high in alumina or silica first to revise the silica-alumina ratio. This can be done in all cases with a high degree of accuracy by first assuming the slag to contain 45 per cent CaO, and then making the correction as shown above from a knowledge of the stone analysis. After this is done the procedure used in arriving at the data given in Table II is the same as was used.

We will consider in conclusion the case of a Lake ore of the following composition:

|                                        | Per Cent |
|----------------------------------------|----------|
| Fe, .....                              | 55.4     |
| SiO <sub>2</sub> , .....               | 6.8      |
| Al <sub>2</sub> O <sub>3</sub> , ..... | 1.6      |
| CaO, .....                             | 0.3      |

Using the same coke analysis previously given and assuming a fuel consumption of 1800 pounds of coke per ton of pig, calculations made in a manner similar to those in the case of the Tennessee ore mixture will, for a basic iron containing 1 per cent Si and 94 per cent Fe, furnish the data given in Tables III and IV. Here, however, the calculations have been extended to include the revised silica-alumina ratio mentioned above, for a limestone of the composition already stated.

TABLE III.

|                                                            |       |
|------------------------------------------------------------|-------|
| Lb. pig iron per lb. ore                                   | 0.589 |
| Lb. SiO <sub>2</sub> from ore per lb. pig                  | 0.115 |
| Lb. Al <sub>2</sub> O <sub>3</sub> from ore per lb. pig    | 0.027 |
| Lb. SiO <sub>2</sub> from coke per lb. pig                 | 0.040 |
| Lb. Al <sub>2</sub> O <sub>3</sub> from coke per lb. pig   | 0.024 |
| Lb. SiO <sub>2</sub> , reduced to Si                       | 0.021 |
| Lb. SiO <sub>2</sub> from stone (assuming 45% CaO in slag) | 0.013 |
| Lb. Al <sub>2</sub> O <sub>3</sub> from stone              | 0.004 |
| Lb. SiO <sub>2</sub> , available for slag                  | 0.147 |
| Lb. Al <sub>2</sub> O <sub>3</sub> , available for slag    | 0.055 |
| Revised silica-alumina ratio                               | 2.7   |

TABLE IV.

| Percentage Composition |                                |                  | Active Range          |                        | Width of Active Range, Deg. C. |
|------------------------|--------------------------------|------------------|-----------------------|------------------------|--------------------------------|
| CaO                    | Al <sub>2</sub> O <sub>3</sub> | SiO <sub>2</sub> | Viscosity = 4 Deg. C. | Viscosity = 10 Deg. C. |                                |
| 37                     | 17.0                           | 46.0             | 1.548                 | 1.410                  | 138                            |
| 38                     | 16.7                           | 45.3             | 1.527                 | 1.411                  | 116                            |
| 39                     | 16.5                           | 44.5             | 1.527                 | 1.408                  | 119                            |
| 40                     | 16.2                           | 43.8             | 1.527                 | 1.405                  | 122                            |
| 41                     | 15.9                           | 43.1             | 1.516                 | 1.395                  | 121                            |
| 42                     | 15.7                           | 42.3             | 1.508                 | 1.390                  | 118                            |
| 43                     | 15.4                           | 41.6             | 1.498                 | 1.383                  | 115                            |
| 44                     | 15.1                           | 40.9             | 1.474                 | 1.361                  | 113                            |
| 45                     | 14.9                           | 40.1             | 1.453                 | 1.346                  | 107                            |
| 46                     | 14.6                           | 39.4             | 1.458                 | 1.364                  | 94                             |
| 47                     | 14.3                           | 38.7             | 1.506                 | 1.388                  | 118                            |
| 48                     | 14.0                           | 38.0             | 1.618                 | 1.432                  | 186                            |

In Table IV a well-defined minimum active range is noted at 45 per cent CaO. For basic iron, therefore, this slag composition is indicated, although for foundry iron a higher furnace temperature, corresponding to 42 or 43 per cent CaO, might be advantageously used. Adhering, however, to the question of basic iron, it is readily calculated that the weight of CaO needed per pound of pig iron is equal to  $0.202 \times \frac{45}{55}$  or 0.165 pound. The lime present in the ore, amounting to 0.3 per cent, will yield  $\frac{0.003}{0.589}$  or 0.005 pound CaO per pound of pig iron. Assuming, as before, that 3.8 per cent CaS is present in the slag, it is readily calculated that the amount of limestone which should be charged is equal to  $\frac{0.165 + 0.012 - 0.005}{0.485}$  or 0.355 pound per pound of pig.

## CONCLUSIONS

It seems reasonable to conclude that the slag-viscosity tables are destined ultimately to become as useful to the metallurgist and blast-furnace operator as the steam tables are at present to the mechanical engineer, although this does not preclude the possibility of their being revised and expanded from time to time.

It remains for each individual furnaceman to make the greatest possible use of the information contained in the viscosity tables.

It is not unreasonable to conclude that viscosity measurements similar to those already made on iron blast-furnace slags will be performed in the case of both copper and lead slags with the same relative measure of successful industrial application.

The dependence of fuel economy on the maintenance of the proper slag composition has not been elaborated in the present paper. It is a fact so well-known to metallurgists that it hardly requires any explanation. With this in mind, it becomes clear that, aside from any question of increased pig-iron production, an intelligent slag control in the blast-furnace is a most important step toward enormous savings in our available coal supply.

Cleveland, O.

Statistics on the German production of potash for 1917 are given in a dispatch from Vice-Consul J. C. McNally, at Zurich, Switzerland, as follows:

|                                 | Per Cent         | Tons    | K <sub>2</sub> O Tons |
|---------------------------------|------------------|---------|-----------------------|
|                                 | K <sub>2</sub> O |         |                       |
| Carnallite, .....               | 9-10             | 4,290   | 400                   |
| Raw salts, .....                | 12-15            | 393,360 | 52,200                |
| Fertilizing salts, .....        | 20-22            | 201,190 | 42,250                |
| Fertilizing salts, .....        | 30-32            | 23,870  | 7,400                 |
| Fertilizing salts, .....        | 40-42            | 321,760 | 131,900               |
| Potassium chloride, .....       | 63               | 166,370 | 105,300               |
| Potassium sulphate, .....       | 42               | 31,350  | 13,170                |
| K. Mg (SO <sub>4</sub> ), ..... |                  | 1,452   | 150                   |
|                                 |                  |         | 352,470               |

## Electric Welds

### Notes on Welding Machinery, the Properties and Microscopy of the Welds and a Peculiar Occurrence of Widmanstättian Structure

By ERNEST EDGAR THUM

WITH the advent of high-power electric welding machines both for spot and butt welding, an increasingly large number of joints are being made in this manner. Special machines have been developed for butt-welding of various shapes ranging from the smallest wire to heavy tires; for the manu-

voltage from about two to ten volts and perhaps as many thousand amperes, and then passing this heavy amperage through the pieces to be welded while they are pressed tightly together with the joint about midway between the gripping vises. In comparison with the rest of the secondary winding, these pieces of

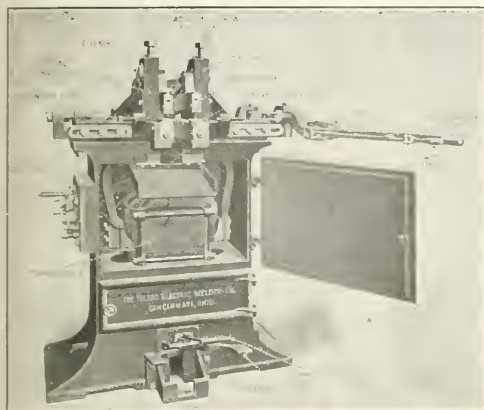


FIG. 1.—ELECTRIC BUTT WELDER

facture of teapot spouts, all sorts of enameled ware, tubes and pipe. Spot welding machines of various sizes are also in operation, which instead of welding a continuous seam will fasten two or more plates together at isolated spots, making a joint much after the style of a riveted connection.

#### ELECTRIC WELDING MACHINES

The usual butt welder (Fig. 1) consists of a suitable pair of heavy copper clamps or vises for holding the work. One of these clamps is attached to a fixed and one to a sliding head, the latter of which can be moved toward the other with considerable force during the welding operation by manual operation of a compression lever. The work to be welded serves as part of the secondary circuit of an alternating current transformer, built into the base of the machine. This secondary usually has but one turn, a heavy water cooled copper bar bent up and ending in the vises mentioned above. The primary winding will contain fifty or more turns, depending upon the voltage of the power line and the voltage required to overcome the resistance of the pieces to be welded.

The operation of the machine, therefore, involves drawing a few kilowatts of electric power from a suitable supply, transforming it into a current ranging in



FIG. 2.—UPSET WELD

FIG. 3.—FLASH WELD

material to be welded have a small cross section and high specific resistivity; the passage of the current is consequently attended by the development of a large amount of heat at the joint, where the pieces rapidly attain a very high temperature. The constant pressure applied through the clamping arms forces the two together as the softening or welding temperature is attained, upsetting a considerable amount of plastic metal

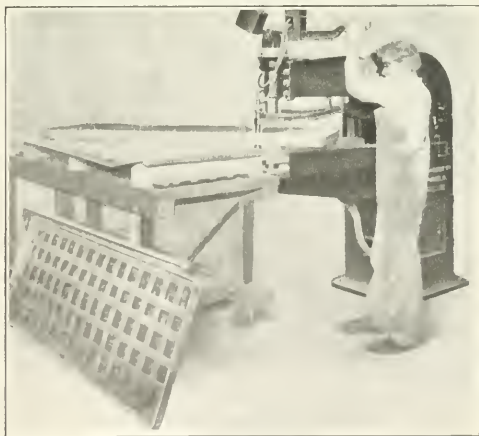


FIG. 4.—SPOT WELDER BUILDING LATTICED FRAMES

as in Fig. 2, or, if the pressure and current are held a longer time, extruding considerable burned metal in the form of a perpendicular fin (Fig. 3). The current is now shut off, the piece cooled and annealed (if the latter operation is thought necessary), and the weld is completed by grinding off the fin.

## SPOT WELDING

The operation of the spot welder is in no wise different. As shown in Fig. 4, the gripping vises are replaced by heavy copper dies or electrodes which close upon the sheets to be welded. The current is switched on and heats intensely the metal throughout a small region between the copper terminals, and the sheets are welded over a roughly circular spot. Extrusion of metal in this case is prevented by the continuous lateral support which the cold sheet affords the heated area; however, a small crater-like depression is formed by the pressure of the die upon the plastic metal (Fig. 5).

A welding operation may be regarded merely as a process of bringing the particles of two separate pieces of material within the region of their mutual molecular attraction either by means of heat (increasing their plasticity) or by pressure (increasing their proximity) or by both heat and pressure. If time and sufficiently close contact is afforded, the molecules of the one piece migrate into the other even in the cold and form an alloy at that point. It follows that the making of an electric weld is an exactly similar operation to that of welding on an anvil. The great advantage lies in the efficient method of producing the heat electrically, and the pressure mechanically. This results in an enormously increased speed of operation, and indirectly it eliminates the formation of undesirable metallic oxides on the heated surface which are so troublesome to the blacksmith. This is due to the fact that the heating is done so much more rapidly than in the forge, out of contact with the heated air blown through a bed of

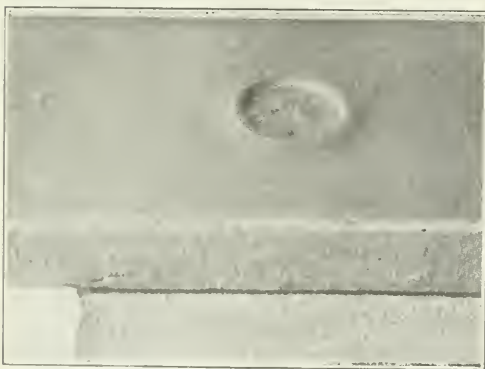


FIG. 5.—SPOT WELD JOINING TWO STEEL SHEETS

coals, and withal so quickly and efficiently that only a small amount of oxide is formed, and this is immediately eliminated in the fin of hot metal squeezed out from the welded zone.

## WELDING HIGH SPEED TOOLS

Shortly after the outbreak of the war, speculation in metals forced the price of high speed or tungsten steels for machine tools to such an exorbitant figure that an ordinary lathe tool became a piece of precious metal, difficult to procure at any price. Many plants resorted to the expedient of spot welding a small inset of high speed steel into a notch cut in the end of a carbon steel tool (Fig. 6). This was a very economical

procedure, inasmuch as the welding operation is quite inexpensive, and the stub end of an old lathe tool of high speed steel too short for the holder could be cut up and used to make the working edge of several standard size tools.

Considerable trouble was experienced, however, from the tendency of the high speed inset to break off, cracking through at a short distance above the welds.<sup>1</sup>

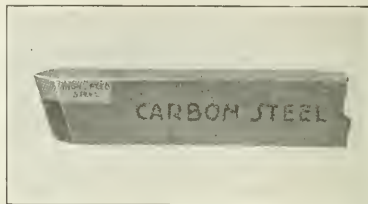


FIG. 6.—LATHE TOOL WITH CUTTING POINT OF HIGH SPEED STEEL

A microphotograph of the weld showed very little interpenetration of the two metals, the alloy which was formed at the junction by the welding current being about 0.0006 inch in thickness.

The troubles following welding of high speed steel resembled the familiar "season cracking" of bronzes. These latter cracks probably result from failure along surfaces which are under initial stresses (set up, in the case of brass and bronze, by cold working). The strains resulting from these stresses are usually beyond the power of direct observation under the microscope, and no evidences of structural weakness could be observed in the steel inset, even though studies of low carbon welds showed considerable evidence of slip bands, as will be seen in what follows.

It was found, however, that cracking in service could easily be eliminated by placing the tool in a hot oven immediately after welding, before the piece had a chance to cool, and annealing to a dead soft state by cooling in lime, later hardening and tempering the tool in the proper manner. The time at the annealing temperature was apparently sufficient to allow the molecules which were strained in some manner during welding to adjust themselves to the orientation required for stability at low temperatures.

## WELDING HIGH CARBON STEELS

In order to throw some light upon the chemical and physical changes induced by the welding process, pieces of 0.97 per cent carbon drill steel, of  $\frac{3}{8}$ -inch diameter, were studied after butt welding. Test pieces of the original stock and of both annealed and unannealed welds were made by mounting in a lathe, removing the excess metal of the fin, and then turning or grinding a short length of the bar accurately to a diameter of one-half inch, with the weld in the center of the turned portion. In the unannealed welds, the turned portion was but one-half inch in length in order that the failure would be forced to occur within the portion of the bar altered in constitution by the welding heat. Tension tests of the unannealed welds showed, in all cases, a

<sup>1</sup>The writer investigated this and other phenomena attending electric welding for the Thomson Electric Welder Company of Cincinnati during 1916, and through their courtesy is enabled to present the more interesting results of his examinations.



failure with little or no necking occurring at the end of the turned portion—that is to say, farthest from the weld and in the softest portion of the test piece. The strength thus developed was much higher than even the strength of the original steel, and it is clearly evident that all parts of this weld have a higher ultimate strength than the original bar. The average results of the tension tests follow:

| Material                | Ultimate Strength<br>lb. per Sq. In. | Contraction<br>in Area,<br>Per Cent | Elongation<br>in 1 in.,<br>Per Cent |
|-------------------------|--------------------------------------|-------------------------------------|-------------------------------------|
| Original tool steel     | 114,100                              | 12                                  | 10                                  |
| Unannealed weld         | 158,700                              | 2                                   | 3                                   |
| Weld annealed at 750° C | 100,800                              | 24                                  | 16                                  |

### ANNEALED WELDS

In the annealed bars failure always occurred at the weld, accompanied by considerable necking, strictly limited to the close proximity of the point of failure. The marked increase in ductility of the steel at the weld suggested the possibility of a very considerable change in carbon content at that point. Metallographic examination substantiated this suspicion—eye examination of a polished surface showed a zone some one-eighth of an inch long which etched much lighter than the boundaries, and under the microscope exhibited primary ferrite in pearlite. Fig. 7 shows a micrograph of the edge of this decarbonized zone, indicating an unmistakable variation in carbon content from the eutectoid stock at the left toward the decarbonized weld. Conviction became certainty upon analyzing saw dust from cuts through the weld and through the stock; the former gave 0.57 per cent and 0.51 per cent for two different welds, while the original stock returned 0.97 per cent carbon.

An explanation of this variation of the carbon content is not apparent. The welding current is on but a few seconds; for the matter of a second or thereabouts the temperature is so high that considerable iron is burned in the plastic material squeezed out by the pressure, but then the current is immediately interrupted and the piece rapidly cools. Undoubtedly a small amount of iron oxidizes at the surface to be welded, but this is entirely extruded, no oxides of iron nor blowholes of carbon monoxide being observed in any section. Again, the axis of the bar—which while the hottest, is also the furthest from the atmosphere—evidences the maximum amount of decarburization. How a weld can be made without blowholes, or how a piece of steel can be decarbonized without the deleterious effects attending so-called "burning" are points yet to be investigated.

Some microscopic examinations gave hints of a carbon migration away from the welded spot back into the unaffected stock. However, the problem of demonstrating a high carbon zone between the weld and the stock was attacked by a senior student at the University of Cincinnati with negative results. One hardly conceives the existence of a driving force during this operation capable of transporting carbon any great distance in the few seconds a butt weld is at a reasonably high temperature, and yet the speed of penetration of oxygen into the steel and carbon monoxide outwardly appears incredibly rapid. Numerous gas cavities, on the other hand, form readily when spot welding rusty structural steel.

### UNANNEALED WELDS

The unannealed weld in eutectoid steel furnishes a perfect specimen for metallographists. The thermal gradient of the heated pieces rises sharply from slightly above room temperature at the vise to a maximum at the joint. In like manner, the axis of the rod is materially hotter than the surface. Just before the current is switched off, an ellipsoidal-shaped core of well defined boundaries has been heated to and beyond the critical temperature with the result that within this zone the steel is then austenitic, that is to say, the iron carbide is absorbed in solid solution; while just without these boundaries the steel has been annealed to the sorbitic state (or remains in the pearlitic condition, if that were the structure of the original bar). Fig. 8 shows the transition of a slowly cooled hypo-eutectoid steel at the left into the cloudy sorbite at the right, beautifully illustrating in one view the entire mechanism of cementite absorption.

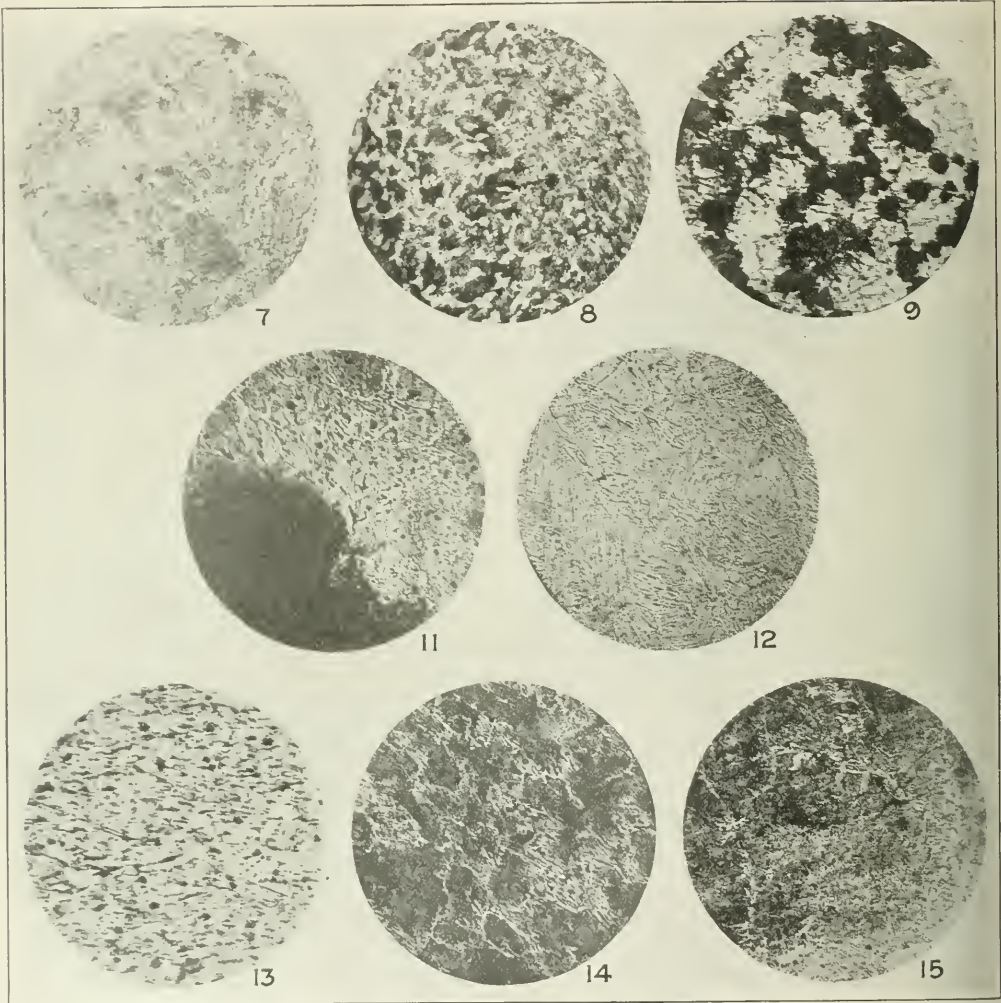
Immediately upon interrupting the electric current, the austenitic core is "quenched," in that its surrounding cold and unaltered sheath abstracts heat very rapidly by conduction, with the result that the core exhibits every possible decomposition product between austenite and pearlite, regularly arranged in bands. The lines of demarcation are sometimes so clear that the naked eye can observe a dark band developed by the quick etching so characteristic of troostite. An instance of this is given in the micrograph shown in Fig. 9, where the lighter martensite on the right changes into the dark-etching spots of troostite on the left in a narrow zone bounded approximately by the width of the field.

Within the space of about twice the diameter of the piece, a weld before annealing possesses a core whose center exhibits nearly the maximum hardness attainable after quenching such a steel. Entirely surrounding this core are layers or muffs of similar form and definite boundaries which gradually change in hardness and toughness to that of the original stock—in case the latter was in a soft condition before welding. In welding hardened steels, on the other hand, the outer muff surrounding the core, being in the sorbitic condition, is liable to be softer than the stock. Barring the decarbonized zone, this entire alteration can be obliterated by proper annealing, after which the entire tool or any part of it can be given any requisite hardening or tempering.

The statement can be drawn from the above remarks that a welded bar, not heat treated, will break at some distance from the joint under static load, but at the weld if tested under sharp, eccentric impact. After heat treatment, the exact opposite will occur, as the joint will then be the weakest and most ductile part of the bar, due to a local decarburization.

### WELDING STRUCTURAL STEEL

In order to show a comparison, in a qualitative way, of the strength of a rivet as compared with that of a spot weld, four 3 x 8-inch bars were cut from 3-inch stock structural steel plate. Two of these were riveted together with two 3-inch rivets, one driven 1½ inches from either end; while the other pair were spot welded at corresponding points with a machine designed to give a weld 2-inches in diameter. The bars were then



FIGS. 7-9, 11-15

Fig. 7—Edge of decarbonized zone in annealing weld; x 220. Fig. 8—Absorption of ferrite into austenite in an unannealed welded low carbon; x 120. Fig. 9—Abrupt transition of martensite into troostite in butt welded eutectoid steel; x 220. Fig. 10—Blowhole in weld in structural steel; x 260. Fig. 11—Eutectiform structure developed in structural steel; x 260. Fig. 12—Structural steel, unaffected by welding; x 260. Fig. 13—Center of weld in structural steel; x 260. Fig. 14—Transition from sorbitic to eutectiform areas in structural steel; x 260.

laid flat on end supports, bent through about 45 degrees by a concentrated central load, and sawed lengthwise throughout, cutting through the center of the connec-

tion. A sketch of the bars, Fig. 10, will best show the results—the bars riveted together slipped past one another shearing the rivet, while the bars welded together showed absolutely no movement at the ends, nor



FIG. 10—COMPARISON OF STRENGTH OF WELDED AND RIVETED JOINTS

tion. A sketch of the bars, Fig. 10, will best show the results—the bars riveted together slipped past one another shearing the rivet, while the bars welded together showed absolutely no movement at the ends, nor

did a microscopic examination of the weld show any indication of plastic yielding.

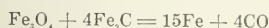
The stress acting on the neutral surface of a beam is one of horizontal shear, tending to move the upper and lower sections in opposite directions. The rivets in the above case were working under ideal conditions, and showed a perfect shearing failure.

The spot welds were working under exactly the same loading. However, in their case, the soft, low carbon rivet steel, working at a disadvantage in being under a considerable initial stress, is replaced by the hardened higher carbon structural steel, an integral part of the metal both above and below. In riveting, good metal is removed to make way for softer, while in welding,



a joint of harder and stronger metal is built up which is continuous with both the pieces connected.

A number of small pits were noticeable after sawing through the weld, an enlarged view of one of which is shown in the accompanying micograph, Fig. 11. The rounded black area at the left is the blow-hole, surrounded by a zone of light-colored ferrite, which in turn is backed by the hardened steel of unchanged carbon content, just indicated in the dark spot at the upper edge. This appearance is readily explained as follows: The sheets were taken from a stock pile and no attempt made to clean them of rust or scale before welding. At the time of welding, little chance was given for any extrusion of hot metal, owing to the continuous lateral support of the heated area; in this manner any impurity which originally existed on the surfaces of the plates would be trapped and retained. The temperature of the weld is sufficient to effect a double decomposition of the oxide of the scale and carbide of the pearlite, thus:



The gas remains as a bubble in the center of a plastic mass of decarbonized iron.

#### EUTECTIFORM STRUCTURE IN SPOT WELDS

A very peculiar structure appears to a greater or less extent in all the spot welded low-carbon steel plates, but was not observed in any of the butt welds examined. It was found best developed near the outer edge of the spot welded structural plates of Fig. 10 and is shown in Fig. 12, at 260 diameters. The parallel striations, somewhat wavy, suggest pearlite, which it evidently cannot be, since the original metal is ordinary structural steel, whose microsection gives the typical hypo-eutectoid appearance (Fig. 13). A spheroidal mass at the center of the welds shows the microstructure of Fig. 14, a darkened background with the excess ferrite just being precipitated toward the edges of the crystalline grains. This entire central area, which etches dark in general, and which has been hottest during welding, is bordered by the peculiar light-etching eutectiform structure of Fig. 12, and which has not been so hot. The transition is extremely narrow, as is shown in Fig. 15 of the structural steel, and less clearly in Fig. 16 of a higher carbon spot weld. In turn, the eutectiform area grades into the unaffected original stock less abruptly.

This structure resembles martensite very much and one is tempted to class it as such, especially since unannealed welds are quite hard, and since this eutectiform structure is found adjoining sorbite. It is possible that the rapid conduction of heat by the relatively large and cold areas surrounding a spot weld, chilled and hardened the localized heated area of the weld and at the same time produced an inter-strain in the weld region which assisted in the formation of the martensite. While it is true that the exact center of a butt-welded joint is often troostitic and surrounded by a shell of martensite, this martensite in turn grades into the original stock through the well-known decomposition series without the development of this peculiar structure, which apparently requires a higher specific pressure for its production. In all the spot welds where this structure was observed the carbon content was moderate; low-carbon steels would not be expected to develop

such large quantities of martensite nor would martensite be expected separating zones of sorbite and pearlite.

The markings within the borders of more than one crystalline area of Fig. 12 are notably straight and parallel, suggestive that the mass is one of very closely twinned metal, appearing like the structure shown in Fig. 17, which shows twinning striations in rock minerals. While so-called "annealing" twins are formed in steel by heating it above the transformation range after slight deformation, these crystalline entities so common in brass, for instance, show relatively broad parallel-sided strips crossing the crystal from boundary to boundary (Fig. 18).<sup>2</sup> Doubtless the local conditions of heat and pressure during the welding process might readily be such as to cause annealing twinning, but such are very rarely observed in alpha iron.

Narrow twins, such as these under investigation might prove to be, are known as Neumann bands (Fig. 19), but these are commonly thought of as being "mechanical" twins, that is, produced by shock in rigid metal rather than by squeezing the hot plastic metal between the dies of a spot welder. Neumanns are readily disclosed after etching, as are these markings, but the former are destroyed by heat above  $A_c$ , which temperature may easily have been exceeded in the weld, since the latter areas border a sorbitic structure.

#### X-BANDS AND SLIP BANDS

Certain aspects of Howe's X-bands (Fig. 20) show a noticeable resemblance to these markings under investigation. The X-bands occur on polishing and etching iron after a severe deformation. However, all the illustrations given in "The Metallography of Steel and Cast Iron" are of X-bands in ferrite, even though one infers from the text that they were also observed in 14-point steel. They appear before any heating has been applied—indeed, rest and temperature both obliterate them. It is probable that if any X-bands were formed early in the welding operation they would be healed during the heating near  $A_c$  and would not appear in a polished section taken some months later. Likewise, slip bands (Fig. 21) are ordinarily observed on deforming a polished surface, and the amorphous or twinned layers between the moving laminae are not sufficiently wide to reappear after repolishing and re-etching. Thus, while doubtless the strain under spot welding is sufficient to develop slip bands profusely, they could be expected to leave no trace after polishing and etching a specimen.

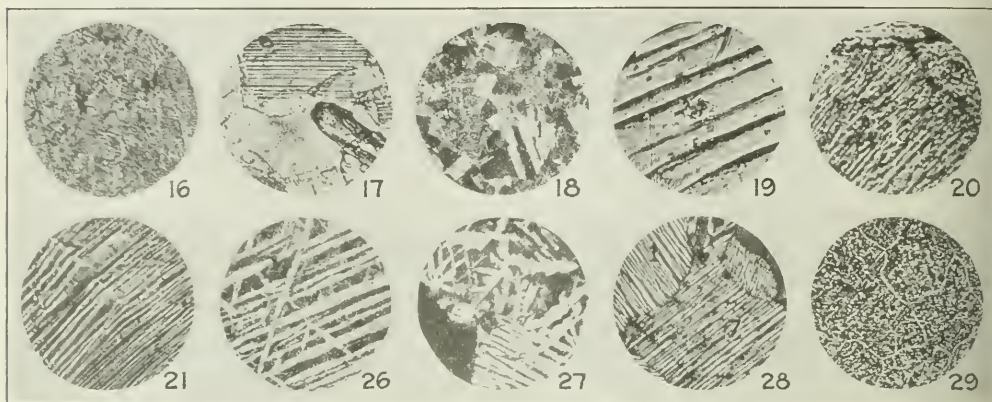
In the above discussion which successively eliminated the possibility that this peculiar eutectiform structure represents either annealing twins, mechanical twins, X-bands, or slip bands, it has been tacitly assumed that the various grain areas delineated in Fig. 12 by the ends of the parallel markings represent crystals of homogeneous metal. Since hypo-eutectoid steel of such low carbon content could not be expected to develop such large areas of pearlite, one naturally wonders what has caused the entire suppression of the carbonaceous areas so prominent in the center of the weld (Fig. 14) and in the original stock (Fig. 13). Entire decarbonization of this cool, surface zone resulting in pure ferrite is not likely, since a study of butt welds

<sup>2</sup>Figs. 17, 18, 19, 20, 21, 27, 28 and 29 are from Howe, "The Metallography of Steel and Cast Iron."



shows that decarbonization depends upon degree of heat rather than proximity to surface. Furthermore, the decarbonization at a blow-hole is not deep seated nor complete, as is very evident from an examination of Fig. 11. Unquestionably the original carbon is still

ward rapidly while the high-temperature lines shrink into nothingness with even greater speed. Evidently some particular zone between the outmoving and in-shrinking isotherms remain at about the same temperature for a comparatively long time. Fig. 25 shows



FIGS. 16—21, 26—29

Fig. 16—Transition from sorbitic to eutectiform structure in spot welded hypo-eutectoid steel;  $\times 260$ . Fig. 17—Twinning striation of plagioclase. (Rosenbush);  $\times 45$ . Fig. 18—Twins in copper;  $\times 50$ . Fig. 19—Neumann bands;  $\times 500$ . Fig. 20—X-Bands in ferrite after 30,000 lb. compression per sq.in. Fig. 21—Regular slip bands in ferrite;  $\times 500$ . Fig. 26—Widmanstätten structure of ferrite;  $\times 50$ . Fig. 27—Closely packed W-bands;  $\times 80$ . Fig. 28—Eutectiform pattern in austenitic manganese steel;  $\times 90$ . Fig. 29—Cementite assembled on grain boundaries and octahedral planes in manganese steel, showing subsequent agglomeration;  $\times 50$ .

there and any explanation of the nature of the structure represented by Fig. 12 must account for its apparent disappearance.

#### TEMPERATURE DURING WELDING

A study of the probable course of heating and cooling in the neighborhood of the spot welded zone may be useful at this juncture. Suppose the assembled plates to have been gripped by the welder dies and the current turned on. After a short time interval, say one-half second, the temperature gradient existing in the plates directly between the dies may be something like that sketched in Fig. 22. A few arcs carry the current across the narrow air gap, heating the metal intensely—locally to the fusion point. In the diagram two small arcs are shown, with a 1000-deg. isotherm back into the metal somewhat. The intense heat very rapidly radiates by conduction back into the metal, giving isotherms like that shown for 500 deg., the temperature gradient being steepest in the regions nearest the arcs. This radiating heat reinforces the Joule effect of the high amperage flowing through the iron resistance, and their combination forms a 100-deg. curve about as shown.

At the end of the next time interval, a number of localized arcs have effected the weld over a considerable area and the heat from the resistance offered by joint and metal have pushed the isotherms back to the approximate condition shown in Fig. 23. At the end of the third time interval the current is shut off, when the heat gradient is approximately as mapped in Fig. 24, since the weld is completed in a matter of a second or two. The hot interior, now robbed of its heating current, is rapidly quenched by its surrounding colder metal, the low-temperature isotherms still moving out-

this hypothetical condition at the end of the fourth time interval.

It is hardly necessary to sketch the location of the temperature lines further. Within a very few seconds the 500-deg. isotherm begins to contract and even the 100-deg. isotherm halts and reverses its direction, starting back to its origin. The main point is that there is formed a hot zone, flatly ellipsoidal in shape where the temperature is above the welding heat, and a larger, fatter ellipsoidal volume where the temperature has exceeded the transformation range momentarily or for some time. Immediately thereafter the hot center is "quenched" by radiation into the cold surroundings, the interior at a much higher rate than the outer fringe, which latter may well remain stationary in temperature for some time.

#### AUSTENITE CRYSTALS FAULT ALONG CLEAVAGE PLANES

The austenitic spheroid, being directly between the dies of the welding machine, is under considerable compressive stress, but is unable to flow any measurable distance owing to its uniform side support by relatively rigid metal. Extrusion of a fin as in a flash weld (Fig. 3) is evidently impossible, but the highly stressed crystals of austenite develop their characteristic octahedral cleavage planes exactly similar to those accompanying the surface slip bands appearing in a polished surface after its underlying metal has been severely strained. On cooling through the transformation range the austenite tends to precipitate its excess ferrite—each crystal rejects the solute to its boundaries, hence the ferrite tends to gather along the cleavage planes. Thus, the central portion of the weld as shown in Fig. 14 is largely of dark-etching troostite or sorbite, but close

examination shows a well defined hair-like precipitation of the excess ferrite fringing many of the allotriomorphic crystalline boundaries, and numerous very fine, white, parallel striations crossing at 60 deg. appear in one of the dark areas near the center of the original micrograph. Very definite "fringes" of larger parallel ferrite needles extending inward from the grain boundary are shown in Fig. 15, near the edge of the sorbitic zone.

Just outside the darker-etching zone (in the region of eutectiform structure) a peculiar conjunction of pressure and temperature evidently occurred. During welding the temperature passed the transformation range, and the pearlitic areas passed into austenite. Migration of carbide to equalize the carbon content of these original austenitic crystals must have been extraordinarily rapid. The austenite crystals were at the same time fractured along their octahedral cleavage by the compressive stress of the welding dies, exactly as indicated in the discussion of the underlying dark-etching areas, and on cooling, after the electric current had been interrupted, each little lamina bounded by the parallel cleavage planes acted as an independent crystal in expelling ferrite to its surfaces. Hence the ferrite marks the sub-microscopic cleavage planes; or rather, the thinnest plate of eutectoid remains at the nucleus of each crystalline lamina. After polishing and etching,

agglomeration of the thin plates into balls of less superficial area, which is the normal appearance of low carbon steel (Fig. 13).

#### WIDMANSTÄTTIAN STRUCTURE

Widmanstätten structure, cleavage structure, or more shortly W-bands (Fig. 26), were named in honor of their discoverer, who found them in meteorites over a century ago. W-bands appear often in steel castings, and according to Sauveur<sup>2</sup> the excess constituent of steels cooling rapidly through the transformation range will largely precipitate between the cleavage planes of the small octahedra composing each grain, "probably because the necessary time is denied for this excess constituent to reach the boundaries of the grains."

The eutectiform appearance has therefore been shown to be identical in nature with the W-bands—it consists of a concentration of excess ferrite along the octahedral cleavage of austenite. The straightness of the striations (extremely perfect in some grains) is indicative of crystalline cleavage, while in many small crystals intersections at 60 or 120 deg. may be observed. Indeed, toward the right of Fig. 12<sup>3</sup> one star-like burst of rays shows five of the six possible directions starting from one point. The W-bands developed in spot welding have little in common with the appearance of Widmanstätten structure as ordinarily illustrated (Fig. 26), but the

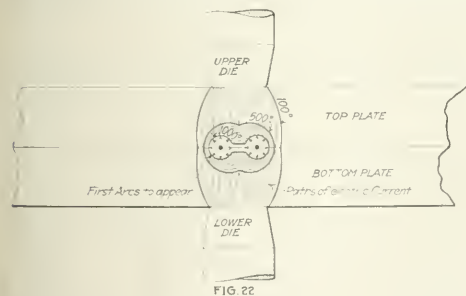


FIG. 22

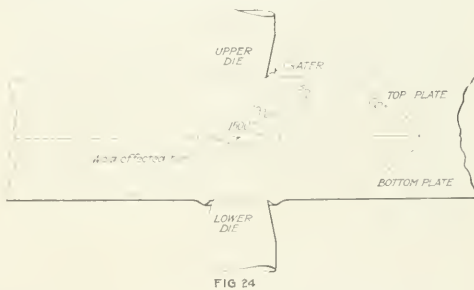


FIG. 24

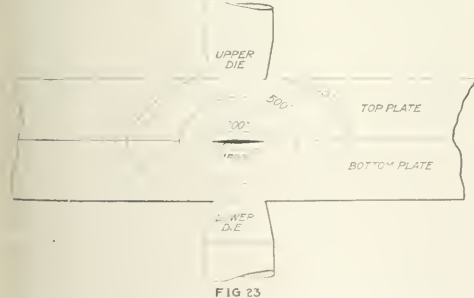


FIG. 23

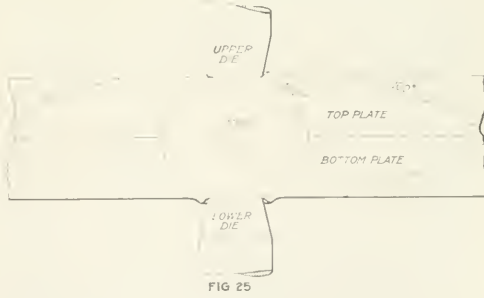


FIG. 25

Fig. 22—Ideal representation of temperature gradient in the spot welding operation shortly after the current is turned on.

Fig. 23—Location of isotherms at the termination of the second time interval.

Fig. 24—Location of isotherms at instant when weld is completed and the current switched off.

Fig. 25—Location of isotherms a very short time after welding is completed.

the eutectoid films etch dark as a series of straight lines crossing from boundary to boundary of the original crystalline entity. Evidently the process of extruding the ferrite from the original austenitic laminae was just completed when the cooling of the zone in question prevented the further molecular mobility necessary for the

close packed W-bands of Fig. 27 would appear quite similar on a lower magnification. Howe and Levy<sup>4</sup> observe the same general appearance in overstrained and

<sup>2</sup>"The Metallography and Heat Treatment of Iron and Steel," page 212.

<sup>3</sup>Beyond the edge of the half-tone and therefore not shown.

<sup>4</sup>Trans. A.I.M.E., Vol. 51 (1915), p. 881.

heated austenitic manganese steel (Fig. 28), caused by the same train of events, that is to say, first fracturing the original austenitic crystals of the quenched metal along their cleavage planes, and thus forming a multitude of new crystalline entities. Then on annealing below the transformation range, the sluggish austenite reverts slowly to beta and alpha iron, extruding the excess and now insoluble cementite to the cleavage—in other words, to the boundaries of each individual plate-like crystal. Further heating will agglomerate this extruded cementite into nodules as shown in Fig. 29 of such considerable size as to be indentified with certainty by differential etching.

#### PRACTICAL DEVELOPMENTS

Spot welding—two years ago a comparatively unknown process—has risen rapidly in favor, giving great promise of effecting enormous savings in money, time and labor in the fabrication of structural shapes, steel railway cars, and ships. In building structural members the plain pieces of plates, angles, and beams are clamped together in their proper relation and stitched together with a spot welder, one weld appearing in place of each rivet. The saving in templet-making, laying out, punching, reaming, and match assembly is obvious. In car bodies and crane runways especially, there are no rivets to work loose after the shaking impact and vibration of long service. The elimination of electrolytic corrosion between rivet and plate would be a determining factor in many cases which would decide in favor of a homogeneous spot weld.

The engineer will naturally pause, however, until sufficient and varied data have been accumulated to convince him that the new will not be inferior to the present method in strength and shock resistance. It is thought that the decarbonization and hardening effects occurring at the weld and so evident in the higher carbon steels will have little effect upon the efficiency of a mild steel connection.

### Japanese Copper Industry

The refining and manufacturing of copper forms the most important native metal industry in Japan, the exportation alone amounting to about 100,000,000 yen (\$49,800,000) per year. The classes of copper articles exported and imported for 1917 are given in the following table:

| Articles                | Exports      | Imports     |
|-------------------------|--------------|-------------|
| Ingot and slabs         | \$43,747,551 | \$1,791,428 |
| Plates and sheets       | 682,352      |             |
| Wire                    | 2,189,152    |             |
| Insulated electric wire | 1,559,457    | 25,454      |
| Manufactures            | 118,579      |             |
| Waste or old            |              | 136,566     |
| Other                   | 1,525,210    | 19,419      |
| Total                   | 49,822,301   | 1,972,867   |

The ingots and slabs are imported from Korea, which, while a part of the Japanese Empire, has a separate customs administration. The waste or old copper consists principally of copper coins imported from China. Submarine cables, chiefly imported from Great Britain, constitute the greatest part of the insulated electric wire imported. The remaining imports, therefore, classified under the heading of "other," do not amount to more than \$20,000 per year, and consist of small shipments of extra high grade wires, tubes, and miscellaneous articles. It can be readily seen that there is

not a large market in Japan for American copper manufactures.

At present, owing to the decreased orders from Russia and the fact that the United States and many of the allied countries have set a price on copper below that at which the Japanese producers are willing or able to sell, there are large stocks of copper on hand. The present price in Japan is around 63 yen per 100 kin, which comes to about \$23.60 per 100 pounds.—CONSUL ROBERT FRAZER, *Commerce Reports*.

### Preparation of Belt Dressings

Many secret preparations of belt dressings, selling at a high price relative to the actual value of their ingredients, are on the market. In the main these consist of (1) mixtures of fats, waxes, tallow or degreas with castor or other fatty oils; (2) vulcanized corn or cottonseed oil thinned with a solvent (gasoline or benzol); (3) preparations containing wood tar, and (4) preparations containing pine rosin, which should never be used, as gums cause the leather fibers to mat together and become brittle. Too frequent application of oils softens the leather and makes it flabby and stretchy. Of the natural occurring materials, beeswax melted in castor oil is the preparation par excellence, not having any tendency to gum up or rot the leather. About one ounce of naphthol or phenol to the gallon of this dressing will aid materially in preventing mildew from injuring belting in damp localities.

Where a good and less expensive dressing is desired, properly prepared vulcanized corn or cottonseed oil proves worth the time of getting the chemicals and making up. The production of a soft, spongy, rubber-like substance by adding from 18 to 25 per cent of sulphur chloride to rape oil was started on a commercial scale by Parkes in 1855 (British patent, Oct. 22, No. 2399). Leather oils based on this sulphur-oil product were first developed in America about the year 1889 by A. Sommer of the Viscol Company. If 17 per cent of sulphur chloride is added to corn, rape or cottonseed oil, the oil will rise about 70 deg. C. in temperature after about ten minutes of reaction and a very viscous, almost solid, gel will be produced.

In producing large quantities of this vulcanized oil, overheating is prevented by adding the sulphur chloride in parts at intervals, thus allowing the mixture more time to cool. After the reaction is complete, the product is treated with sodium carbonate, together with a small amount of a mixture of alcohol and benzol (50-50). All free acids are immediately neutralized by the alkali, but as there tends to be a slight splitting off of acid for a considerable period, a small amount of good tallow soap dissolved in alcohol should be added to introduce a permanent neutralizer. The viscous vulcanized oil is thinned with any solvent such as gasoline, benzol, carbon tetrachloride, etc., to give a dressing of the desired penetrating power.

In perfecting skill in vulcanizing oils, it is better for the uninitiated to work with small amounts of material until good results are a certainty. A dressing having sufficient softening properties, very good pulley grip and but slight tendency to be drawn out by dust, so that it is quite permanent, can easily be made in the plant laboratory by this method.



# The Cottrell Processes in the Sulphuric Acid Industry

## Description of Installations for the Removal of Dust from Roaster Gases and Acid Mist from Exit Gases—Successful Installations for Treatment at High Temperatures

BY A. A. HEIMROD AND H. D. EGBERT

THE Cottrell processes of electrical precipitation are today fully established in the metallurgical field as a standard means of removing from gases finely divided suspended particles of dust and fume, and as such they will be found in use in many of the largest smelters and refineries throughout the country.

But while this field of usefulness is well recognized it is not so widely known that these same processes are also today beginning to fill a long felt want in sulphuric acid manufacturing plants and seem destined to come into more and more general use in this important industry. It seems quite fitting indeed that this should be the case for it was while engaged in research work on sulphuric acid manufacture that Dr. Cottrell carried out the experiments in electrical precipitation which became the foundation of the processes which today bear his name. In fact it was a mist or fog of sulphuric acid particles which he first precipitated by means of a high potential unidirectional current, and it was for the precipitation of sulphuric acid mist that the first commercial electrical precipitation plant was installed.

### APPLICATION IN MANUFACTURE OF SULPHURIC ACID

The Cottrell processes are today being used in sulphuric acid manufacturing plants for two different purposes: First, for cleaning the hot sulphur-dioxide-bearing gases after they leave the furnaces burning iron pyrites, zinc sulphide ores or other similar materials; and second, for removing and collecting the mist of acid carried by the exit gases coming from sulphuric acid concentrators or from the absorption towers in plants manufacturing the acid by a contact process.

It is the intent of this article to describe typical Cottrell installations designed by the Research Corporation for each of the above mentioned purposes, and in so doing it will be assumed that the majority of its readers need no explanation of the fundamental principles underlying the electrical precipitation processes. Those who may not be familiar with these principles or the terminology involved are referred to the literature on the subject<sup>1</sup> in which will be found a full discussion of the elements of electrical precipitation.

The problem of satisfactorily cleaning the sulphur dioxide gases prior to their oxidation and conversion into sulphuric acid has long been a troublesome one for acid makers to solve. In contact-acid plants it is of

course essential that the gases be completely freed from suspended particles of dust or fume prior to their passage through the catalyst and it is almost equally desirable in the case of chamber plants that the sulphur dioxide gases be thoroughly cleaned if the plant is to operate at high efficiency and produce a clear acid of good quality. In the latter case, however, the problem is complicated by the fact that the sulphur dioxide gases must be cleaned at a very high temperature whereas in contact plants the gases can be cooled during the cleaning process or can be cooled first and then purified.

### SOURCES OF DUST WHICH MUST BE REMOVED

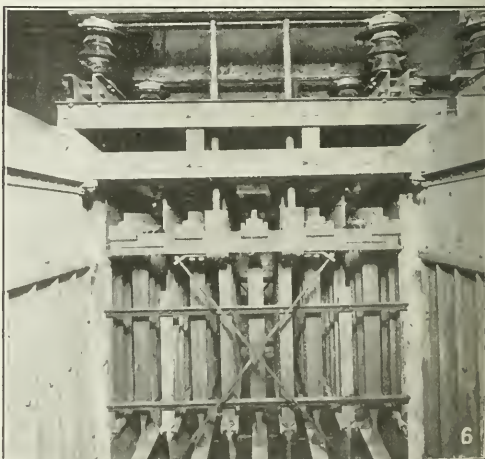
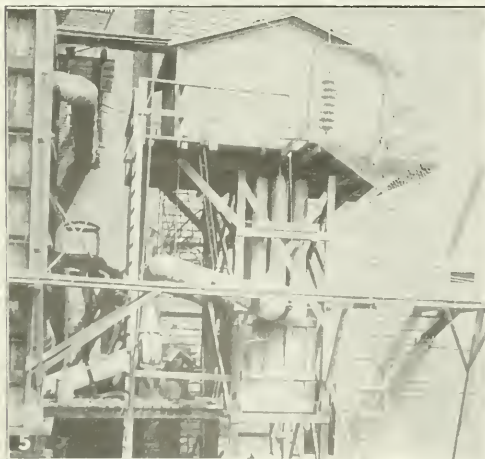
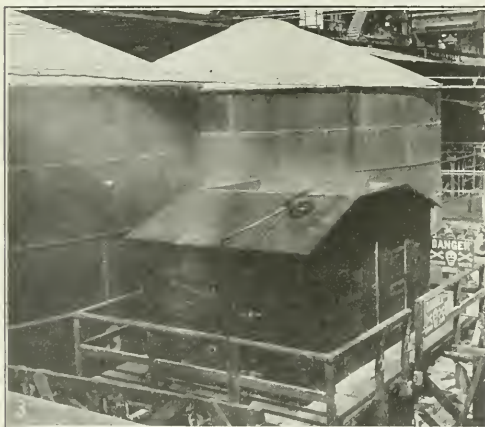
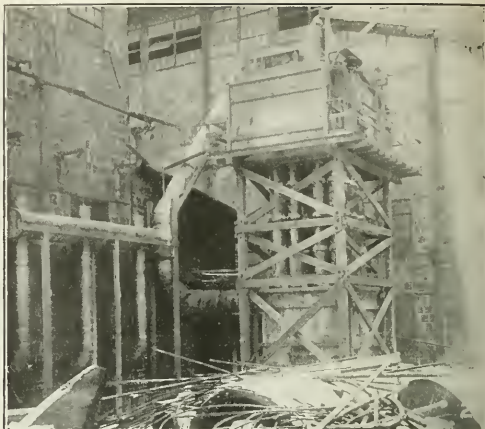
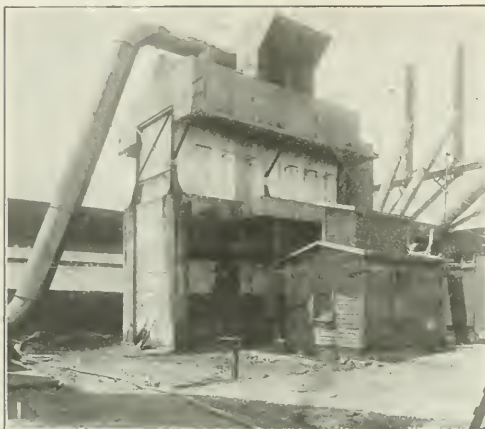
Aside from crude sulphur or brimstone, pyrites, pyrrhotite and zinc sulphide ores are the materials most widely used as the source of sulphur dioxide gases which are later by oxidation converted into sulphuric acid. The roasting of these materials, especially when they are in a finely divided form, gives rise to much dust which must be removed from the gases before their passage through the further stages in the process of acid manufacture.

It is common practice in most acid plants to use furnaces of the type in which the charge is continually agitated while being roasted, and this materially tends to increase the amount of dust carried over by the gases produced by such furnaces, thus making still more important the installation of some means of cleaning the gases. Of course when brimstone is burned the dust problem is eliminated since the gases coming from the burners are practically free from suspended particles of dust or fume.

War conditions have so interfered with the importation of pyrites that many plants are today burning sulphur which under normal conditions would use pyrites and they are thus for the present free from dust troubles. This is only a temporary situation however, and with the resumption of pyrites importation the cleaning of the gases as they come from the roasting furnaces will once again be a necessity. Plants now burning brimstone must therefore look to the future and they should take steps now to provide suitable means for cleaning their furnace gases, as will be necessary when pyrites are again available. Designers of new plants should leave ample space for the installation of suitable gas-cleaning system even though there is no present need for such apparatus because of the use of brimstone instead of other forms of sulphur-bearing materials.

In designing Cottrell precipitators for cleaning roaster-furnace gases the temperature at which the gases must be cleaned and the character of the suspended matter to be removed from such gases are gov-

<sup>1</sup>Problems in Smoke, Fume and Dust Abatement. By F. G. Cottrell. From the Smithsonian Report for 1913. Solution of Smoke, Fume and Dust Problems by Electrical Precipitation, by Linn Bradley. *Metalurgical & Chemical Engineering*, Vol. XIII, No. 15, December 1, 1915. Recent Progress in Electrical Smoke Precipitation. By F. G. Cottrell. Presented before the Second Pan-American Scientific Congress, Washington, U. S. A., December 27, 1915-Jan. 8, 1916.



#### TYPICAL INSTALLATIONS OF COTTRELL PRECIPITATORS

FIG. 1—Cleaning gases from zinc roasters. FIG. 2—Cleaning gases from sulphuric acid concentrators. FIG. 3—Removing sulphuric acid mist from exit gases; current on. FIG. 4—Same; current off. FIG. 5—Removing acid mist. FIG. 6—Interior view of equipment to clean hot roaster gases.

erning factors. Of course the size of the installation depends directly upon the volume of gas to be cleaned and this in turn is fixed by the quantity of material being roasted per unit of time and by its sulphur content as well as by the percentage of sulphur dioxide in the gases leaving the furnaces. These factors must therefore be known or approximated in order that a precipitation plant of suitable capacity may be provided. Two types of precipitators are today being installed for cleaning the hot furnace gases in sulphuric acid plants. These types differ widely from each other and the decision as to which type should be installed is based largely upon the temperature and fume or dust conditions to be met in the particular plant under consideration. In cases where the gases must be cleaned

shortly be used for the manufacture of sulphuric acid by the contact method.

#### CLEANING ZINC ROASTER GASES

With three kilns in operation the volume of gas passing through the precipitator at the above-mentioned temperature is 17,500 cubic feet per minute and there will be collected under such conditions about 7600 pounds of material per twenty-four hours having the following analysis: Zn 22 per cent, Fe 30, Pb 2.2, S 30.

The precipitator as installed consists of two units each having 36 collecting electrode tubes or pipes. These pipes are of steel, 12 in. in diameter and 15 ft. in height. The discharge electrodes are No. 10 jack chains suspended in the vertical axis of each pipe. Means are provided for rapping both the discharge and collecting electrodes in order to remove from time to time any dust which may have adhered to them. The levers for operating the pipe rappers may be clearly seen in the photograph. The bottom header is a reinforced concrete chamber into which the collecting electrode pipes project and in which the collected material is deposited. This is later removed by hand through doors which are provided for this purpose. Should it be desirable, similar installations could be readily provided with hoppers and screw conveyors so that the collected dust could be taken out of the precipitator continuously and automatically. This precipitator occupies a space approximately 17 ft. wide by 28 ft. long and

has an overall height of about 35 feet. The electrical equipment provided for furnishing the high-potential unidirectional current required by the precipitator consists of a 200 to 65,707 50 85,000-volt transformer operated directly from the plant power line, a mechanical rectifier driven by a 3-hp., 3-phase, 60-cycle synchronous motor also operated directly from the plant power line and a switchboard panel with the necessary instruments and control

apparatus such as circuit breaker, rheostats etc. The amount of power required to operate the installation is about 18 kw.

#### OPERATING AT A TEMPERATURE OF 1100 DEG. F.

Fig. 7 is a drawing giving the general arrangement and overall dimensions of a precipitator of the horizontal-flow or plate type, designed and installed by the Research Corporation, and Fig. 6 is a photograph taken looking in a lengthwise direction through a precipitator of this kind which was installed in a chamber acid plant near Baltimore, Maryland, and which is particularly designed to withstand the high temperatures at which the gases must be cleaned in such a plant. This installation operates at a gas temperature of 1100 deg. F., while occasionally temperatures as high as 1400 deg. F. have been recorded in the precipitator.

A precipitator of the size shown in Fig. 7 will clean the hot gases produced by the roasting of 40 to 45 tons of fine pyrites per twenty-four hours. With a sulphur dioxide concentration of  $7\frac{1}{2}$  per cent to 8 per

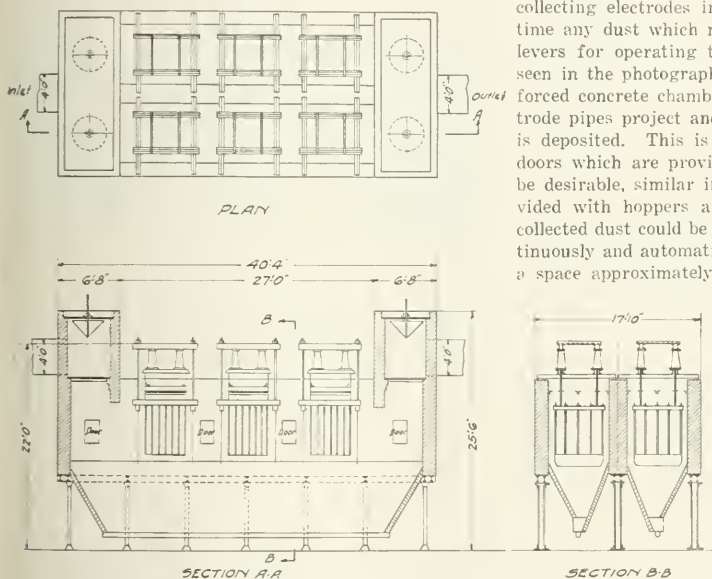


FIG. 7.—GENERAL ARRANGEMENT FOR CLEANING ROASTER GASES

at temperatures of 1000 deg. F. and over, and where the suspended matter to be removed is mostly dust rather than fume, precipitators of the so-called "plate type" in which the gases pass horizontally between the collecting and discharge electrodes have proved highly satisfactory. On the other hand where the gases can be cooled before cleaning to a temperature of about 600 deg. F. or under and where the suspended matter to be removed is fume rather than dust, precipitators of the pipe type in which the gases pass vertically upwards between the collecting and discharge electrodes would in general be the most suitable.

Fig. 1 is a photograph of a Cottrell precipitator of the last mentioned type which was recently installed under the supervision of the Research Corporation at a plant in Wisconsin. Here the gases to be cleaned come from three Mathey rotary kilns, each roasting a little over two tons per hour of Wisconsin zinc ore concentrates having the following approximate analysis: Zn 30 per cent, Fe 30, Pb 0.75, S 35. The gases are cleaned at a temperature of about 500 deg. F. and will



cent this means that the volume of gas passing through the installation is about 17,500 cubic feet per minute at a temperature of 1100 deg. F.

The installation at Baltimore just referred to takes the gases from two 22-ft. diameter, 7-hearth Herreshoff furnaces, each of which burns from 20 to 25 tons of fine iron pyrites per 24 hours. Between 900 pounds and 1200 pounds of dust which is practically all  $\text{Fe}_2\text{O}_3$  is collected per day by the precipitator. The iron content of the acid made with the Cottrell plant in operation is only 0.044 per cent.

As will be noted from an inspection of Fig. 7, the precipitation installation is divided into two sections each of which is provided with a damper at both inlet and outlet ends. This makes it possible to shut off either section from the system when inspection or repair is required or when it is desired to clean the electrodes as may be necessary every few days if a very dusty ore is being roasted in the furnaces. For the above reason it is desirable to so design the plant that each section will have sufficient capacity to handle all the gas for short periods of time and in this way, barring unusual accidents, continuity of operation with clean gas is practically assured.

It has been found by experience that cast-iron jug dampers give the most satisfactory service under the severe temperature conditions which are met with in installations of this character, and room for the installation of dampers of this type should be provided wherever possible.

#### DESIGN OF ELECTRODES FOR HIGH TEMPERATURE WORK

The collecting electrodes of precipitators such as are shown in Figs. 6 and 7 are heavy steel plates reinforced with angle iron stiffeners and suspended in parallel rows in a brick-walled chamber. The discharge electrodes are heavy steel strips or angle irons suspended midway in each of the spaces between the parallel collecting electrode plates.

The discharge electrodes are held in place by frames which are rigidly braced and fastened together at the ends. The frames are suspended from longitudinal T-shaped cast-iron members which in turn rest on transverse beams also made of cast iron but of rectangular shape and cast hollow. These transverse beams are themselves suspended by means of cold-rolled steel rods passing through the roof of the precipitator and supported by a framework carried on insulators placed above and outside of the precipitator. This type of construction is especially advantageous where high gas temperatures exist because the insulators which support the weight of the discharge electrode system are entirely out of the precipitator and thus are removed from all contact with the hot gases. They are therefore subject to no unusual strains and can be easily inspected and cleaned whenever necessary. Insulation must, of course, be provided at the points where the steel supporting rods pass through the roof of the precipitator. This is accomplished by the use of pyrex glass bowls or by oil lutes. In the latter case the oil which is the insulating medium also acts as a seal to prevent the leakage of air at these points.

It is usual to design installations of this type to operate at relatively low voltages in order to simplify the

insulation problem and for this reason a working voltage of only about 50,000 volts is used in actual practice.

The walls of the precipitator are of brick laid up in three courses in which fire brick, insulating brick and ordinary brick are used respectively. Outside of this is placed a steel casing which serves both to strengthen the walls and to prevent the leakage of air. The entire precipitator structure is supported on heavy steel columns and is elevated to a sufficient height above the ground so as to allow for hoppers into which the dust falls as it is removed from the gases. The hoppers terminate in screw conveyors which serve to carry the collected material away from beneath the precipitator.

#### SMALL POWER CONSUMPTION

The power consumption of installations of the above character operating on gases from furnaces roasting iron pyrites is usually quite small. This is the case with the precipitator at the acid plant near Baltimore which has just been described and where the power used is not over 2 kw. The electrical equipment provided at this plant consists of a 200 to 30/35/40/45/50,000-volt transformer operated directly from the plant power line, a mechanical rectifier driven by a 2-hp. 750-r.p.m. 3-phase, 25-cycle synchronous motor also operated from the plant power line and a switchboard panel with the usual control apparatus, instruments etc.

During the concentration of sulphuric acid a certain amount of acid mist is always formed which passes out from the concentrating system with the exit gases. The amount of mist thus carried off depends to a large extent upon the degree to which the concentrator is being forced as well as upon the type of concentrator in use. The mist, however, is almost always present in sufficient quantity to constitute a neighborhood nuisance even if the actual loss of acid is not a serious matter, and some means must be provided to remove it from the concentrator gases before they are discharged into the air. The installation of coke towers and similar scrubbing devices will remove only a portion of the mist and it is therefore not surprising to find that a large number of Cottrell precipitators have been installed and are today satisfactorily solving the acid mist problem in many sulphuric acid concentrating plants.

#### REMOVAL OF MIST FROM EXIT GASES

Precipitators installed for this service are of the pipe type and must of course be constructed of acid-proof materials. Lead is almost always used for the top and bottom headers, while the collecting electrode pipes are of lead or tile as may be found convenient. Figs. 2 and 5 are photographs of two Cottrell precipitators which have been recently installed under Research Corporation supervision to remove the acid mist from the gases coming from sulphuric acid concentrators. Fig. 3 shows the effect of the high potential current on the cloud of acid mist which issues from a precipitator of this type when the current is off as seen in Fig. 4.

The precipitator shown in Fig. 2 treats the gases given off by three concentrators of the tower type producing together a total of about fifty tons of 66° Bé. acid per twenty-four hours. About 3000 cubic feet of gas per minute at a temperature of 135 deg. F. passes through the precipitator and from this is collected about

3000 pounds per twenty-four hours of 18° Bé. acid. The draft necessary for the proper operation of the concentrators is provided by a fan placed between the concentrators and the precipitator and also to a certain extent by a stack to which the gases pass after leaving the precipitator.

One Cottrell unit is provided which has 16 collecting electrode pipes built of sectional tile with joints set up in acid proof cement. All of the pipes are 15 ft. in height and all are 12 in. in diameter with the exception of two of the corner pipes which have a diameter of 16 in. These are made larger to provide for the larger

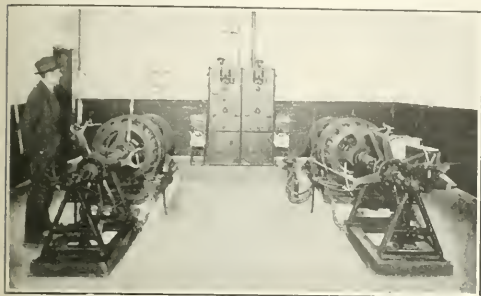


FIG. 8.—TYPICAL INSTALLATION OF ELECTRICAL APPARATUS

and rigid discharge electrodes which are placed in the corner pipes and which serve to hold steady the entire discharge electrode system. The discharge electrode in each of the other fourteen pipes is an iron wire enclosed in a thick star-shaped lead casing. The top and bottom headers of the precipitator are of lead and with the pipes are supported on a timber framework.

Dampers of the jug type are provided and are so arranged that the gases from any one or all of the three concentrators can be shut off from the precipitator at will. Furthermore provision is made so that all the gases can be by-passed around the precipitator to the stack should it be necessary to shut down the installation for the purposes of repair etc.

#### INSULATORS MUST HAVE LARGE SAFETY FACTOR

In Cottrell installations for the collection of acid mist great care should be taken with the insulators supporting the high potential parts of the precipitator. Insulators with a large safety factor as regards voltage rating must be provided and they must be well protected from the acid fumes. In practice it has been found best to depend on the stiffness of the lead covered discharge electrodes to prevent them from vibrating and to provide no insulators in the bottom header of the precipitator. The insulators now generally used in the top header to support the discharge electrode framework are of the corrugated post type made of one piece of porcelain and covered with hoods to protect them as much as possible from the deposition of acid or moisture.

The electrical equipment provided for the installation just described consists of a 5-kva. 200 to 65/70/75/80/85,000-volt transformer operated directly from the plant power line, a mechanical rectifier driven by a 3-hp. 1800-r.p.m. 60-cycle synchronous motor and a switch-

board panel with the necessary control apparatus. The precipitator operates at a potential of 75,000 volts and the power consumption of the installation is about 3½ kilowatts.

The precipitator shown in Fig. 5 cleans 2500 cubic feet of gas per minute at a temperature of 200 deg. F., coming from two concentrators of the tower type producing a total of forty tons of 66° Bé. acid per twenty-four hours. This installation collects approximately 3500 pounds per twenty-four hours of acid having a concentration of 33° Bé.

There is one precipitator unit supported on a timber framework and having twelve collecting electrode pipes each 12 in. in diameter and 15 ft. in height. The pipes in this case are of lead as is also the bottom header. The top header is of frame construction lined with lead. Lead covered iron wire is used for the discharge electrodes. The electrical equipment is of the type previously described and is housed in a small frame building placed close to the precipitator.

#### CLEANING 30,000 CUBIC FEET OF GAS PER MINUTE

One of the largest precipitation installations now in service for the removal of acid mist arising from sulphuric acid concentrators is that which was recently installed to clean the waste gases from twenty-two concentrators of the cascade type, each having a rated output of ten tons of 66° Bé. acid per twenty-four hours. The volume of gas cleaned averages thirty thousand cubic feet per minute at 180 deg. F. and there is collected some twenty-five tons of 40° Bé. sulphuric acid per day. The precipitator consists of four units, each having twelve collecting electrode pipes 12 in. in diameter by 15 ft. in height. The precipitators are constructed of lead throughout and are supported on a timber framework. One set of electrical equipment of the usual type furnishes the power acquired by the installation, switches being provided in the high voltage line so that any precipitator section can be disconnected at will. In the case of each of the installations which have just been described fans placed between the precipitator and the concentrator are used to create the necessary draft.

#### STEAM JETS USED TO INDUCE DRAFT

In some instances steam jets have been used for this purpose but these are not as satisfactory and the acid reclaimed by the precipitator is in such case of a much lower concentration due to the condensed moisture from the steam jet which is precipitated with the acid mist. That portion of the steam which is not condensed prior to passage through the precipitator is, of course, not removed from the gas but passes out and condenses on being discharged into the cooler air. Thus the usual clearance obtained by a precipitator treating the gases from a concentration system in which steam jets are used as a source of draft is not complete, due to the cloud of condensed steam produced at the precipitator exits. The acid mist, of course, is completely removed in either case.

In plants manufacturing sulphuric acid by the contact process there is often a considerable amount of acid mist escaping from the absorption towers, especially when the plant operating conditions are abnormal. When the plant is located near a residential

or in a highly cultivated agricultural district the mist escaping at such times may be a cause of considerable nuisance or damage to surrounding property owners. In such cases also the Cottrell processes have been successfully applied for the removal and collection of the acid mist from the exit gases.

There are still other points in the process of sulphuric acid manufacture where the Cottrell processes of electrical precipitation might be applied with interesting results leading to additional economies and improvements in operation, and experiments are about to be conducted by the Research Corporation looking toward further development along these lines in the near future. The cleaning of the roaster gases and the removal of acid mist from concentrator and absorption tower exit gases is, however, an established commercial use of the Cottrell processes and one in which they are coming more and more into universal use.

Research Corporation, New York City.

### Conservation of Technical Engineers

**T**ECHNICAL engineers of every branch of the profession who are taking part in the war activities of the Army and Navy are alarmed at the unfortunate waste of technical training caused by the drafting and enlisting of engineers for regular service with little or no regard for their technical attainments. These technically educated and experienced men are essential to the successful conduct of the war and cannot be replaced. There is continuing evidence that America is repeating in some measure England's mistake of sending technical men into the ranks when they should be carefully conserved for special duties in the fighting forces or on the technical staffs of the Army, the Navy and the essential war industries.

These facts have been forced upon the attention of engineers who have been co-operating with the Government through the Naval Consulting Board, the National Research Council and Engineering Council. Upon these organizations requests have constantly been made for engineers, chemists and other technical men for a great variety of military services. Thousands of names have thus been furnished to the Government departments and bureaus. Engineering Council especially has devoted attention to this personnel work through its committee, known as American Engineering Service, which has available classified lists of approximately 25,000 engineers, and besides unclassified lists of many more. It is from these lists, directly or indirectly, that most of the names have been selected for war service.

Engineering Council was founded by the American Society of Civil Engineers, American Institute of Mining Engineers, American Society of Mechanical Engineers and American Institute of Electrical Engineers; and other engineering societies are co-operating with it in this service, the total membership represented by these organizations being approximately fifty thousand. Already from 10 to 15 per cent of the members of these several organizations are in the uniformed services of the country and it is safe to say that a large majority of their remaining members are in the Government civilian service or otherwise directly or indirectly engaged in the War. Engineers do not seek

to avoid fighting, but earnestly desire to be given opportunities for fighting and other services in which they can be most effective and which cannot be performed by others.

It is known that through the Committee on Classification of Personnel in the War Service Exchange (of the War Department) and some other ways, efforts are being made to counteract the tendencies toward the loss of our technical men in the ranks of the Army and Navy. It is believed, however, that these efforts are insufficient and that they should at once be supplemented by other stringent measures dealing with the subject in the Draft Boards and recruiting stations.

In view of the foregoing, Engineering Council, created to provide means for united action and to speak authoritatively for its member societies on all public questions of common interest to engineers, respectfully offers the following:

WHEREAS, technically trained engineers are indispensable to the Army, the Navy and the war industries, in engineering corps, ordnance bureaus and signal corps, in aviation, submarine and tank service, in shipbuilding, and in many other assignments; and

WHEREAS, through draft and otherwise many of these irreplaceable men have been and are being diverted so that their special qualifications are not being utilized, be it

*Resolved*, that in the opinion of Engineering Council technically trained men of all ages should be enrolled and conserved for technical duties, and special efforts should be made immediately by the War and Navy Departments to find and record such men among drafted and enlisted forces and to assign them to places in which their special qualifications are needed, and be it further

*Resolved*, that Engineering Council offers to assist the War and Navy Departments in locating and classifying such men, if its assistance be desired, provided these departments will give the necessary facilities for collecting information about engineers now in the Army and Navy, or whose names are upon the selective draft lists.

These resolutions are offered solely in a patriotic spirit of helpfulness. They are published here with the assurance to the Secretaries of War and the Navy that the resolutions have our hearty approval and are worthy of favorable consideration.

### Japanese Coke Production

The statistics on metallurgical coke for the past year are published by *The Chemical Technology* of Tokio as follows:

|                             | Tons    |
|-----------------------------|---------|
| Government Iron Works.....  | 365,000 |
| Mitsui's Miike .....        | 100,000 |
| Tokio .....                 | 80,000  |
| Osaka .....                 | 48,000  |
| Makiyama .....              | 40,000  |
| Shosho Yoko .....           | 40,000  |
| The Kamedo .....            | 30,000  |
| Munakata at Osaka .....     | 24,000  |
| Asahi at Fukuoka.....       | 20,000  |
| Yamashita at Osaka.....     | 15,000  |
| Yamashita at Nagasaki.....  | 15,000  |
| Yoshio at Tokuoka.....      | 10,000  |
| Matsushima at Nagasaki..... | 10,000  |
| Iika .....                  | 3,000   |
| Total .....                 | 800,000 |



# The Metallography and Heat Treatment of Metals Used in Aëroplane Construction—IV

## Uses of Copper and Its Alloys in Aeroplane Construction—Requirements for Sheets and Tubes—Details of the Brazing Process, Methods of Heating, Fluxes and Preparation of Parts

By F. GROTTTS

Chief Metallurgist, Curtiss Aëroplane and Motor Corporation.

### COPPER

**C**OPPER is used as tubing for gas lines and in sheets for tanks and propeller tips. The average chemical analysis is about 99.80 per cent Cu.

Copper sheet should be free from buckles, seams, discolorations and capable of being bent flat without cracking. In order to meet the bend test annealing is sometimes necessary. Annealing consists in heating the copper to such a temperature as will give the required softness and then quenching in water. In most cases 1000 to 1100 deg. Fahr. have been satisfactory temperatures for annealing.

#### PHYSICAL PROPERTIES RAW STOCK

|      | Tensile Strength, Lb. | Elongation, % |
|------|-----------------------|---------------|
| Soft | 30,000                | 25            |
| Hard | 35,000                | 18            |

In the following experiments on annealing it is noticeable that the ultimate tensile strength remains nearly constant while the yield varies inversely with the increase of temperature:

| Temp. | Time, Min. | Quenched, or Cooled | Tensile Strength, Lb. | Yield Point, Lb. | Elongation, 1 in Cent |
|-------|------------|---------------------|-----------------------|------------------|-----------------------|
| 600   | 30         | H <sub>2</sub> O    | 31,200                | 14,740           | 40.5                  |
| 600   | 30         | Air                 | 30,000                | 13,500           | 43.0                  |
| 800   | 30         | H <sub>2</sub> O    | 30,900                | 12,080           | 47.0                  |
| 800   | 30         | Air                 | 32,150                | 12,700           | 45.3                  |
| 1,000 | 30         | H <sub>2</sub> O    | 31,200                | 11,740           | 46.2                  |
| 1,000 | 30         | Air                 | 31,000                | 10,800           | 46.8                  |
| 1,200 | 30         | H <sub>2</sub> O    | 31,450                | 9,900            | 48.0                  |
| 1,200 | 30         | Air                 | 31,700                | 10,000           | 47.0                  |

#### FAILURES DUE TO FAULTY WORKMANSHIP

Several cases of copper sheet failing have been found. They were noticed because of gasoline leaking out. Examination showed fine cracks extending out from the soldered joints, as shown in Fig. 89. These fine cracks were due to faulty workmanship, and the vibration from the motor caused the copper to give way.

By faulty workmanship is meant cases where the solder is allowed to flow out in jagged points from the joint. It creates a stiffness which will localize any vibration. Ofttimes the tanks are so designed as to cause certain parts to be subject to unnecessary stress. Copper under stress will soon fail when subjected to excessive vibration. It was thought by some to be necessary always to solder copper joints with soft solder or silver solder, but brazing material works very nicely, especially for tubing.

Joints between copper and brass can be made with brazing material, but solder or silver solder is safer, minimizing danger of burning the brass.

Sheet copper on propeller tips often fails because of mashing or straining in tacking on. Dents from hammers start cracks, and because of the speed of the pro-

peller these open up. Many cases have been reported as crystallization in the copper from the rapid motion, but to date such a failure has not been found here. Such examples have been found to start from either excessive or careless hammering, or straining the copper sheet in place.

The use of the blow torch on copper tanks should be discouraged because of danger of gassed copper, illustrated in Fig. 90.

The reducing element, hydrogen, of the torch combining with oxygen forms water. This water which is immediately converted into steam forms hair cracks which grow rapidly when stressed or vibrated.

#### TESTS FOR COPPER TUBING

Copper tubing for gas lines, etc., as made from cast ingots: This is hot-pierced and rolled, then finished by cold-drawing to the desired strength. This material is given three tests:

**Flattening test**—A section of tubing two inches long is flattened with a hammer until it will pass through a micrometer set to three times the thickness of the tube wall; no cracks should appear.

**Crush test**—A section one and one-half inches long must be crushed endwise to half its original length without cracking.

**Bend test**—Tubing as it is must be bent at an angle of 180° with a radius of half the thickness of the wall. Annealed specimens taken from the tubing should not crack when hammered to a fine edge. Joints in this materials were for a time only made from silver solder, as there were many cases of burned tubing. Brazing material makes a good joint and is much cheaper. The temperature necessary for successful brazing is not high enough to spoil any tubing. As copper tubing is bent into many shapes it is necessary to anneal it. The following tests were made on copper tubing of an analysis of 99.87% Cu.

| Temp.     | Time, Min. | Quenched         | Ultimate Strength, Lb. | Yield Point, Lb. |
|-----------|------------|------------------|------------------------|------------------|
| 400       | 30         | H <sub>2</sub> O | 35,700                 | 15,350           |
| 600       | 30         | H <sub>2</sub> O | 35,250                 | 13,430           |
| 800       | 30         | H <sub>2</sub> O | 35,600                 | 12,980           |
| 1,000     | 30         | H <sub>2</sub> O | 35,200                 | 9,130            |
| 1,200     | 30         | H <sub>2</sub> O | 33,400                 | 8,940            |
| 1,400     | 30         | H <sub>2</sub> O | 34,000                 | 7,630            |
| Raw stock |            |                  | 28,600                 | 14,950           |

#### BRASSES AND BRONZES

Brasses and bronzes give lots of troubles, as the material oftentimes is internally stressed by cold drawing to get a high tensile strength. These stresses are not shown by chemical analysis, physical tests nor microscopic examination. Machining, temperature variations,



FIGS. 89-96

Fig. 89—Fine crack in copper sheet, extending from soldered joint. Fig. 90—Gassed copper resulting from use of blow torch. Fig. 91—Tobin bronze before treatment with mercurous nitrate. Fig. 92—Tobin bronze after treatment with mercurous nitrate. Fig. 93—Manganese bronze. Fig. 94—Film of oxide in brass bar. Figs. 95 and 96—Cracks resulting from over-heating

corrosive agents, vibration, will cause the strains to become cracks. These cracks are sometimes called season cracks. They are peculiar to brasses and bronzes of less than 80 per cent copper. This type of alloy has a greater percentage of the brittle copper-zinc constituent than where the material runs over 80 per cent copper.

Annealing helps to remove these stresses and increases the elongation. The average temperature in annealing is about 700 deg. and the quenching is done in water. Water-quenched material seems to give more even results than air-cooled.

TOBIN BRONZE

Tobin bronze used for turnbuckles has an average analysis of 60.24 Cu, 0.67 Sn and 38.59 Zn. In order to remove stresses and meet specifications it is annealed at

different temperatures.

| Temp. | Quenched<br>or Cooled | Tensile<br>Strength, Lb. | Yield<br>Point, Lb. | Elongation<br>Per Cent | Reduction,<br>Per Cent |
|-------|-----------------------|--------------------------|---------------------|------------------------|------------------------|
| 400   | H <sub>2</sub> O      | 69,000                   | 13,450              | 28.5                   | 54.8                   |
| 400   | Air                   | 69,500                   | 13,340              | 29.5                   | 55.6                   |
| 600   | H <sub>2</sub> O      | 67,400                   | 12,750              | 30.2                   | 56.8                   |
| 600   | Air                   | 68,000                   | 13,140              | 26.0                   | 57.9                   |
| 800   | H <sub>2</sub> O      | 65,400                   | 13,140              | 36.5                   | 53.6                   |
| 800   | Air                   | 66,500                   | 12,980              | 35.0                   | 57.8                   |
| 1,000 | H <sub>2</sub> O      | 58,900                   | 11,420              | 46.0                   | 61.1                   |
| 1,000 | Air                   | 59,500                   | 11,500              | 44.0                   | 60.0                   |
| 1,200 | H <sub>2</sub> O      | 60,500                   | 11,000              | 45.0                   | 62.4                   |
| 1,200 | Air                   | 60,000                   | 11,150              | 42.0                   | 61.5                   |

Extensive investigations have proved that turnbuckle barrels when made from stressed bronze will crack when exposed to corroding agents such as ammonium hydroxide and sodium chloride. These failures nearly always trace their origin to trying to get a high tensile strength from drawing. This places the material in a strained condition and the cracks will appear during machining

or when subject to corrosion. It is interesting also that a turnbuckle barrel will sometimes pass inspection and then it will show up with large cracks seemingly from no cause whatever. In order to detect these internal strains a section about two inches long is taken from each rod, cleaned and polished and then immersed in a solution of mercurous nitrate (65 g.  $\text{HgNO}_2$ —15 cc.  $\text{HNO}_3$ —900 cc.  $\text{H}_2\text{O}$ ) for twenty minutes. At the end of that time they are cleaned off and examined. The failure from the stressing will appear at once. The photographs reproduced in Figs. 91 and 92 show the material before and after being in the mercury solution.

Impurities often found are As, Sb, Bi, Fe and Pb. Arsenic is not so detrimental as Sb or Bi, which makes the material brittle, due to the fact that they will not form a solution but form thin layers between the crystals. A small quantity of iron (0.09) is not detrimental. Lead occurs in the Zn as minute globules.

#### MANGANESE BRONZE

Castings are made from lake or electrolytic copper and spelter. This spelter has an analysis of

Pb 0.15, Fe 0.03, Cd 0.15, and Zn remainder.

The castings should be free from blow holes and spongy spots.

The average physical properties are tensile strength, 70,000 lb.; yield point, 30,000 lb.; elongation, 15 per cent. Chemical analysis, 59% Cu, 40 Zn, 0.15 Pb, and 3.0 Sn, Fe, Mn, and Al.

Several cracked sections were found that were caused from the welding in of a part. The strains produced by such an operation can be relieved by subsequent annealing.

#### GUN METAL

Gun metal is made from lake or electrolytic copper (99.88) and pig tin (99.0). It is used for instruments and finishings. It has an average chemical analysis of 87.5% Cu, 10.0 Sn, 2.0 Zn, 0.2 Pb and 0.15 Fe.

Physical properties: ultimate tensile strength, 30,000 lb.; yield point, 15,000 lb.; elongation, 15 per cent.

#### MONEL METAL

Monel metal is used for sheathing of aeroplane propellers. It is cold-rolled and should be clean and of uniform color. It is subject to a bend test, that is, hammered double without cracking. It has been remarkable because of the small number of flaws and defects found.

The average chemical analysis is:

Cu 25%, Ni 66, Fe 3.5, Mn 3.5, Impurities 1.0.

Physical properties: Ultimate tensile strength, 70,000 lb.; yielded point, 35,000 lb.; elongation, 25 per cent.

#### BRASS

Bearings, bolts, nuts and brazing wire are made from brass. Bearings are made from yellow brass which has an analysis of Cu 64.5, Zn 34.8, Pb 3.2, impurities 0.37

Defects found are principally in the form of spongy spots and inclusions.

Bar brass for nuts and bolts in the raw state has the following physical properties: Tensile strength, 65,009 lb.; yield point, 42,500 lb.; elongation, 22 per cent; reduction, 48 per cent.

Chemical analysis: Cu 60.1, Sn 0.45, Fe 0.08, Pb 0.22, Zn remainder.

One bar was rejected because of a thin film of oxide shown in Fig. 94. This flaw showed up when machining and was probably due to carelessness in casting. Oxide was not all removed and afterward showed up in the bar.

#### FLUXES FOR BRAZING BRASS

Joints are made in tubing and sheet-steel by brazing. The parts to be joined should be carefully cleaned in order that the brazing material may have a good surface to adhere to. Fluxes such as borax are used to do away with any oxides formed.

The sheet or tubing should not be sandblasted before brazing as the material will not flow readily and overheating of both steel and bronze sometimes results.

There are two brazing materials used, one having an analysis of 80% Cu, 0.3 Pb, 0.1 Fe, 1.25 impurities, Zn remainder; and the other having about 58 to 60% Cu and 40 to 42 Zn.

The first is preferable as the steel can be heat-treated afterward without damage to the braze.

Ammonium chloride, zinc chloride and sodium chloride (salt water) will sometimes give a reddish brown appearance to the braze. This indicates a slight dezincification, which means the braze is spongy and weak. Failure has been known to result from such joints.

#### CONSIDERATION OF THE BRAZING PROCESS

Brazing is a method of joining the parts of higher-fusing metals, usually steel or copper, by the use of a lower-fusing copper-zinc alloy, usually called "spelter," or in the case of steel or iron parts, of copper alone.

The parts to be joined are heated a little above the fusing point of the metal used to make the union, a substance applied, called a flux, which will fuse and dissolve all the metallic oxides present, and the brazing metal applied in such a manner that it will melt and flow into the spaces where the union of parts is desired. The parts are then allowed to cool in air, after which the joint is finished by removing the adhering flux and the superfluous brazing metal.

Brazing is sometimes referred to as "hard soldering," in distinction from "soft soldering," in which the uniting metal is a tin-lead alloy.

When a silver alloy is used as the uniting metal the process is called "silver soldering."

There is no single term which includes all of these methods.

In the brazing process the following items should be considered:

Composition and character of the brazing metal

Methods of heating parts

Composition of the flux

Preparation of the parts for the process

Cleaving the joint after being made

Effect of the process upon the metal of the parts joined.

*Brazing metal*—The "spelter" commonly sold in the trade is a "low brass," i.e., a brass having a comparatively low copper content, the object apparently being to keep the melting point as low as possible. The copper content should never be less than 55 per cent, as any further reduction very rapidly weakens the alloy.

The ultimate strength of a brazed joint clearly depends upon the strength of the brazing metal forming the union. Other things being equal, therefore, the metal



having the greatest strength should be used; but there are several conditions which affect the choice. This is the attraction which causes a liquid to "wet" a solid. In the case of brazing the attraction of the molten spelter for the iron, or other metal of the joint, exceeds that of the flux, so that it attaches itself to the other metal. There must also be no physical obstruction to this wetting action.

It is probable that there is a superficial alloying of one or both metals in the spelter with the iron, which forms the actual union, since the adhesion of the spelter to the iron is always stronger than either the iron or the spelter. In testing butt brazes of mild-steel rods either the brass or the steel parted; the brass never separated from the steel.

The "flow" of the spelter depends upon the wetting attraction, and the absence of physical obstructions. The chief physical obstruction is metallic oxide which forms on the surfaces of the heated metals, especially upon the surface of the molten brazing metal. Unless the oxides formed are instantly dissolved in the flux they form a film on the surface which prevents the union of the metals. It is highly important, therefore, that the brazing metal contain no metal whose oxide is insoluble in the flux used.

**Fluxes.**—The most satisfactory fluxes for brazing with copper-zinc alloy are borax, and boric or boracic acid. The latter is preferable because it contains no water of crystallization and melts down without frothing. Borax contains a large amount of water of crystallization, which is driven off in the first heating, causing it to froth violently, which causes it to be blown off by the torch or blast flames.

Iron, copper, and zinc oxides are freely soluble in molten boric acid, forming their respective borates.

Tin and aluminium oxides do not form borates. The presence of these metals in brazing spelter must therefore be considered as deleterious impurities; they interfere with the flow, and if in any considerable quantity prevent it altogether.

Copper and brass have the peculiarity of dissolving their own oxides, and these will interfere with the flow of the metal. Brazing spelters should be clean metal, i.e., free from dissolved oxides, and impurities in suspension.

In practice a brass having a higher copper content than that usually given as having the greatest tensile strength was found to make the strongest joint. The best results were obtained with a brass having practically the composition specified by the Signal Corps, viz:

|                        | Per Cent  |
|------------------------|-----------|
| Copper .....           | 78 to 82  |
| Lead (maximum) .....   | 0.3       |
| Iron .....             | 0.1       |
| Total impurities ..... | 1.25      |
| Zinc .....             | Remainder |

Experiments indicate that the iron content can be considerably higher than the amount given above without harm, while the maximum of allowable impurities appears high. But brazes made by the acetylene torch with metal containing 83 per cent copper showed a greater tensile strength, in a number of cases, than the steel, the joint holding while the steel parted.

Brazing metal is changed in composition and, where the acetylene torch is used, may be changed in crystal-

line structure, by the process. In gas-fire brazing it loses about 2 per cent of zinc, and in acetylene brazing it may lose as much as 6 per cent. The difference in color cannot be due to the change in composition, since brass of the same composition is pure yellow; it is probably due to a difference in the nature of the solid solution forming the alloy, the pink tint arising from the presence of beta crystals. This theory would also account for the considerably greater strength of joints brazed by the acetylene torch. The difference in crystalline structure is clearly shown in the micrographs of the braze of acetylene and fire-brazed joints.

Pure copper is inferior to good brass as a brazing metal. It requires a considerably higher temperature, with increased labor and danger of burning the steel, does not flow as well, and the finished joint is weaker.

**Methods of Heating.**—The essential in making a good brazed joint is to have the parts of such a temperature that the brass flows freely, but not hot enough to "burn" the metal. This requires special care in the use of the acetylene flame in cases as light-gage tubing. Cases were found in which the tubing had been melted through and the hole covered with spelter. On the other hand, if the temperature falls too near the freezing point of the brass it forms a coarse, granular, brittle structure, thus weakening the joint. The intense heat of the acetylene flame tends to produce bubbles in the braze, probably by the rapid evaporation of zinc. This can be avoided, or reduced to a minimum, by taking a little more time and not trying to force the heating.

The acetylene flame produces the strongest joint, the gas-fire the next best, and dip-brazing the weakest. The weakness of the dip-braze is no doubt due to the fact that, as ordinarily practiced, the steel does not become any hotter, and possibly not as hot, as the molten brass. Dip-brazing should, therefore, be used only for joints in which there are large contact surfaces, such as reinforcements of tubing, and similar constructions. The average increase in strength of acetylene-brazed joints over fire-brazed in a series of experiments was 8.5 per cent.

**Preparation of Parts.**—Steel parts should be free from adhering foreign matter, and from scale; the ordinary film of oxide does not matter. Sand blast should never be used to clean joints before brazing. The rough surface produced greatly interferes with the flow of spelter; and in the effort to overcome this, the workman overheats the steel, with the result that cracks, both in the brass and the steel, develop on cooling. Figs. 95 and 96.

The supposition that sand adheres to the steel and prevents the flow of spelter is erroneous; microscopic examination of the surface showed it to be perfectly clean. The effect is entirely physical. Where the size of the parts would admit they could be very effectively cleaned by tumbling with sand or other suitable material, which would leave the surfaces smooth and polished. "Pickling" with acid is unsafe, as it is very difficult to so completely remove the last traces as to prevent subsequent corrosion.

Parts to be united are held together either by pinning, or "tacking" with welds made by the acetylene torch. Pinning is generally used in assembling parts with tubing. Pins should be cut flush and "set" by spot-welding

the ends with the acetylene torch. Except where they are very large it is difficult to rivet them as they buckle in the tube. If left without being set they are of no practical use after the joint is finished, whereas they would form a large factor of safety if welded. Where joints are assembled by tacking, care should be taken to make the welds as small as possible; if large welds are made the lumps of iron left interfere with the filing of the joints after brazing.

Joints formed by crushing parts together while red hot, as in forming eyes on the ends of tubing, contain so much scale that it is not dissolved out by the flux, and therefore the spelter does not flow into the spaces where union is desired. In such cases the joint should be dipped in spelter and crushed into shape by a die press while the spelter is still fluid. This would insure complete union of parts, and save one operation. Where fillets are to be made the piece must be held so that the natural flow of the spelter will make a fillet of equilateral section. If the piece is not so held the fillet will spread out on one side and draw away from the other, causing extra labor to fill up the joint, and leaving a poor job in the end. A vise having a universal adjustment should be used for holding pieces that are to have fillets put in.

**Cleaning Brazed Joints**—Cleaning a brazed joint involves removing the black iron oxide, or scale, the fused borax, and the excess spelter. Sand blast affords a perfectly satisfactory method of removing scale and flux, except where brazing must be done afterward. For removing excess spelter a small electric or pneumatic hammer, fitted with suitable chisels, would do quicker and better work than filing. Power emery belts, properly arranged, can do most of the work of polishing after the excess spelter has been removed. Where sand-blasting is not feasible the borax can be removed with hot solution of carbonate of soda, which has no bad effect upon either the brass or steel.

**Effect of the Brazing Process on Steel**—The temperature required to melt brass is sufficient to anneal the steel to which it is applied. If the steel has been "tempered" by cold-working such as rolling or drawing, the effect is to increase ductility and reduce tensile strength.

### Coke Prices Reduced

Reciting the fact that contracts for high-priced coal have generally expired, that the supply of coal is more regular and that the price of coal has been reduced ten cents a ton, an order has been issued by the U. S. Fuel Administration making a flat reduction of 30 cents a ton for coke produced in by-product ovens except in the states of Alabama and Washington. The order became effective seven o'clock a. m., September 3.

Under the order the base price for by-product coke is fixed at \$5.70 for run of ovens and \$6.70 for selected foundry, which is a reduction of 30c. per ton from the former base price. Except where otherwise provided, the maximum prices, f.o.b. cars at point of production, for each grade of by-product coke shall be the sum of the base price for such grade, and the freight rate from the competing bee-hive coke district which takes the lowest freight rate to the point where such by-product coke is produced.

## The Terry Differential Flotation Process

THE Terry differential flotation process disclosed in U. S. Letters Patent No. 1,254,173, Jan. 22, 1918, and Canadian Patent No. 184,193, May 7, 1918, is based on the discovery that ammonia in solution promotes oxidation of metallic sulphides by air introduced into the pulp. An experiment illustrating the oxidizing influence of ammonia may be made by wetting clean pieces of iron with water and with ammonium hydroxide. Yellow ferrous carbonate soon forms on the iron wet with water while the piece of iron wet with ammonium hydroxide becomes bright red with ferric oxide. As the oxides of zinc, copper and lead are soluble in ammonium hydroxide and most ammonium salts, these sulphides are cleansed and their flotability is unimpaired, whereas iron oxide is insoluble and the oxide-filmed iron sulphide (pyrite or pyrrhotite) is rendered immune to flotation. As the air drives ammonia out of solution a closed tank and circulation system is the most economical in which to carry on the oxidizing reaction and conserve the volatile ammonia gas.

### FRACTIONAL PERCENTAGE OF AMMONIA REQUIRED

The amount of ammonia required to accomplish this result depends on the character of the ore, pulp dilution or density, time of contact and aeration. Solutions containing from 0.04 to 0.06 per cent  $\text{NH}_3$  were used in the test recorded in the accompanying data. Ammonium hydroxide or ammonia gas may be introduced directly into the pulp or generated *in situ* by decomposition of ammonium salts by alkalies, for example ammonium sulphate and sodium carbonate. The gas is rapidly absorbed or combined with the water forming ammonium hydroxide.

In treating some complex ores containing zinc, copper, lead and iron sulphides, ammonia may be introduced with the frothing agent in the form of an emulsion and good results obtained. With other ores this procedure fails to make a high recovery and it is found necessary to give the ore a preliminary treatment with ammonia and air before introducing the frothing agent.

In the differential flotation of some zinc-copper-iron sulphide ores it was found necessary to substantially remove the ammoniacal solution by decantation and replace with water before adding the frothing agent, otherwise copper sulphide would float with the zinc sulphide. Copper thus floated showed a marked tendency to drop as the ammonia was eliminated in cleaning and recleaning the concentrate and to appear in the midlings.

### NEUTRAL WOOD OILS BEST FOR AMMONIA PROCESS

When ammonia is introduced into ore pulp in conjunction with certain oils, no differential action is manifested and all sulphides are floated. This is particularly true with coal-tar distillates. The most suitable oils for differential flotation are found among the wood products, especially neutral pine oils and neutralized wood creosotes.

As the oxide film or coating on the iron sulphides is only superficial, the best results are obtained in flotation cells giving a maximum amount of aeration and minimum scouring action. This is characteristic of the Callow pneumatic cell. Of mechanical types, the K. & K.

machine is considered efficient. There is evidence but not conclusive proof that an iron machine gives better results than cells which are constructed of other metals or of wood.

A vast amount of valuable information has been acquired relative to differential flotation of metalliferous sulphides, as a result of research for a period of over two years, that can not consistently be given publicity at this time.

Although the accompanying data give some results of tests on zinc-iron sulphide ores, the process is applicable to differential flotation of other metalliferous sulphides, such as molybdenite and graphite, from iron sulphides.

#### SOURCES OF AMMONIA

Ammonia is derived from gas liquor byproduct in the manufacture of coal gas, ammonium sulphate or other salts by decomposition with alkalis. Ammonia is also

#### New Corrugated Concrete Roofing

Since the success of the asbestos-cement shingle has become well established, it is natural to expect larger fabricated parts to appear, which will occupy a place similar to corrugated iron. The British are now marketing this product. Their method of manufacture is reported to be as follows: Finely ground and cleaned asbestos fibre is mixed with portland cement in the proportion of about 1 to 6, and water enough added to make a dough. The material can be colored red with ochre etc. during mixing. The batter then flows on to a Fourdrinier machine of special design and a sheet formed on a felt.

Special waterproofing dopes are added similar to sizing in the paper industry and the sheets are then trimmed to size and corrugated. Special precautions have to be taken to see that the material does not squeeze thin at the tops of the corrugations, so that the

#### RESULTS OBTAINED BY THE TERRY DIFFERENTIAL FLOTATION PROCESS

| Sample No. 1 Ore—100 mesh:             | Percentage Analysis of Ores and Products |       |       |       |       |       | Percentage of Total Metals, Etc., in Various Products |        |        |        |        |                  |
|----------------------------------------|------------------------------------------|-------|-------|-------|-------|-------|-------------------------------------------------------|--------|--------|--------|--------|------------------|
|                                        | Wt.                                      | Zn    | Pb    | Fe    | Cu    | CaO   | Zn                                                    | Pb     | Fe     | Cu     | CaO    | SiO <sub>2</sub> |
| Concentrates.....                      | 21.6                                     | 49.20 | nil   | 11.71 | 0.85  | 1.10  | 1.15                                                  | 85.30  | 18.00  | 93.95  | 3.28   | 1.03             |
| Middlings.....                         | 15.2                                     | 10.10 | ..... | 12.92 | 0.05  | 11.20 | 24.18                                                 | 12.29  | 13.97  | 7.05   | 23.51  | 11.33            |
| Tailings.....                          | 63.2                                     | 0.47  | ..... | 15.15 | nil   | 8.40  | 44.90                                                 | 2.41   | 68.03  | 00.00  | 73.21  | 87.64            |
| Heads.....                             | 100.0                                    | 12.44 | ..... | 14.05 | 0.20  | 7.23  | 32.37                                                 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00           |
| Sample No. 2 Ore—100 mesh:             |                                          |       |       |       |       |       |                                                       |        |        |        |        |                  |
| Concentrates.....                      | 45.2                                     | 50.20 | nil   | 12.63 | tr.   | 0.33  | 1.52                                                  | 91.71  | 21.20  | .....  | 39.41  | 10.44            |
| Middlings.....                         | 11.6                                     | 12.00 | ..... | 34.31 | ..... | 0.75  | 8.00                                                  | 5.61   | 14.78  | .....  | 23.01  | 14.10            |
| Tailings.....                          | 43.2                                     | 1.55  | ..... | 39.85 | ..... | 0.33  | 11.50                                                 | 2.68   | 64.02  | .....  | 37.58  | 75.46            |
| Heads.....                             | 100.0                                    | 23.70 | ..... | 25.94 | ..... | 0.48  | 6.70                                                  | 100.00 | 100.00 | .....  | 100.00 | 100.00           |
| Sample No. 3 Ore—100 mesh:             |                                          |       |       |       |       |       |                                                       |        |        |        |        |                  |
| Concentrates.....                      | 55.2                                     | 49.80 | ..... | 11.98 | nil   | 0.40  | 0.41                                                  | 96.08  | 26.17  | .....  | 45.00  | 15.60            |
| Middlings added to tailings:           | 44.8                                     | 2.27  | ..... | 41.65 | ..... | 0.62  | 2.76                                                  | 3.92   | 73.83  | .....  | 55.00  | 84.40            |
| Tailings.....                          | 100.0                                    | 28.61 | ..... | 25.26 | ..... | 0.49  | 1.45                                                  | 100.00 | 100.00 | .....  | 100.00 | 100.00           |
| Sample No. 4 Ore—100 mesh:             |                                          |       |       |       |       |       |                                                       |        |        |        |        |                  |
| Concentrates.....                      | 30.0                                     | 5.50  | 2.80  | 14.64 | ..... | 0.60  | 1.05                                                  | 61.58  | 68.89  | 16.71  | 13.33  | 4.00             |
| Middlings.....                         | 27.6                                     | 24.00 | 0.93  | 24.60 | ..... | ..... | .....                                                 | 29.86  | 20.87  | 25.86  | .....  | .....            |
| Tailings.....                          | 42.4                                     | 4.00  | 0.33  | 35.60 | ..... | ..... | .....                                                 | 8.56   | 10.24  | 57.43  | .....  | .....            |
| Heads.....                             | 100.0                                    | 22.17 | 1.23  | 26.27 | ..... | 1.35  | 7.78                                                  | 100.00 | 100.00 | 100.00 | .....  | .....            |
| Sample No. 5 Table Middlings—100 mesh: |                                          |       |       |       |       |       |                                                       |        |        |        |        |                  |
| Concentrates.....                      | 51.3                                     | 48.38 | 4.10  | 7.40  | ..... | ..... | 1.30                                                  | 92.5   | 53.1   | 7.9    | .....  | 6.40             |
| Tailings (including middlings):        | 48.7                                     | 4.08  | 3.80  | 38.60 | ..... | ..... | 19.30                                                 | 7.5    | 46.9   | 82.1   | .....  | 93.60            |
| Heads.....                             | 100.0                                    | 26.80 | 3.95  | 22.28 | ..... | ..... | 10.30                                                 | 100.0  | 100.0  | 100.0  | .....  | 100.00           |
| Sample No. 6 Table Middlings—100 mesh: |                                          |       |       |       |       |       |                                                       |        |        |        |        |                  |
| Concentrates.....                      | 36.0                                     | 53.20 | 3.85  | 5.08  | 0.45  | 2.34  | 77.44                                                 | 53.30  | 13.35  | .....  | 9.70   | 3.96             |
| Middlings.....                         | 19.3                                     | 23.60 | 3.52  | 19.18 | 1.55  | 13.26 | 18.41                                                 | 26.12  | 23.35  | .....  | 17.90  | 12.17            |
| Tailings.....                          | 44.7                                     | 2.30  | 1.21  | 22.45 | 2.70  | 39.44 | 4.15                                                  | 20.58  | 63.30  | .....  | 72.40  | 83.87            |
| Heads.....                             | 100.0                                    | 24.73 | 2.60  | 15.85 | 1.67  | 21.02 | 100.00                                                | 100.00 | 100.00 | .....  | 100.00 | 100.00           |
| Sample No. 7 Mill Tailings—80 mesh:    |                                          |       |       |       |       |       |                                                       |        |        |        |        |                  |
| Concentrates.....                      | 5.40                                     | 60.20 | ..... | 2.25  | 1.20  | ..... | .....                                                 | 72.38  | .....  | 2.00   | .....  | 0.29             |
| Middlings.....                         | 13.47                                    | 7.40  | ..... | ..... | ..... | ..... | .....                                                 | 22.04  | .....  | .....  | .....  | .....            |
| Tailings.....                          | 81.13                                    | 0.32  | ..... | ..... | ..... | ..... | .....                                                 | 5.58   | .....  | .....  | .....  | .....            |
| Heads.....                             | 100.00                                   | 4.40  | ..... | 6.06  | 21.96 | 7.48  | 100.00                                                | .....  | .....  | .....  | .....  | .....            |
| Sample No. 8 Table Middlings—80 mesh:  |                                          |       |       |       |       |       |                                                       |        |        |        |        |                  |
| Concentrates.....                      | 33.60                                    | 50.00 | 5.06  | 6.72  | 0.67  | 1.61  | 86.91                                                 | 40.66  | .....  | .....  | .....  | .....            |
| Middlings.....                         | 13.60                                    | 15.60 | ..... | ..... | ..... | ..... | 10.96                                                 | 22.22  | .....  | .....  | .....  | .....            |
| Tailings.....                          | 52.80                                    | 0.87  | 2.86  | 40.56 | ..... | ..... | 2.13                                                  | 36.12  | .....  | .....  | .....  | .....            |
| Heads.....                             | 100.00                                   | 19.33 | 4.18  | 27.12 | 0.92  | 5.00  | 100.00                                                | 100.00 | .....  | .....  | .....  | .....            |

produced from calcium cyanamide or aluminium nitride by decomposition with superheated steam or by direct union of its elements under pressure (17 atmospheres), heat and a catalyzing agent as in the Haber process.

Aluminium nitride is manufactured from aluminium carbide, a byproduct in the electric smelting of aluminium ore (bauxite), and nitrogen from producer gases, or fractionated liquefied air. Calcium cyanamide is obtained by treating calcium carbide produced by fusion of carbon (powdered coal) and lime in an electric smelting furnace, with nitrogen gas as in the manufacture of aluminium nitride.

Ammonia liquor byproduct from coal-gas usually contains approximately 12 per cent NH<sub>3</sub> and has a market value of about ten cents per pound of ammonia content. The success of the Terry differential flotation process, like all others requiring additional agents, largely depends on the cost of such materials. Synthetic nitrogen products are now manufactured in large quantities, and afford a fairly cheap and abundant supply of this reagent.

product will be homogeneous as well as proof against breakage at weak spots. The sheets go from the machine to the seasoning shed, where the cement takes its initial set and cures without being disturbed. The pitch of the corrugations is made on the 3-inch basis similar to English corrugated iron, so that the product is flatter than the 2½-inch U. S. pitch.

Corrugated cement-asbestos sheets will be heavier than the metal ones but will be sufficiently durable for mechanical ware and will have the advantage of being far more resistant to atmospheric conditions, especially in chemical plants where acid fumes are present. It is to be hoped that a suitable synthetic siliceous fiber will be developed to take the place of the asbestos.

Imports of gold during the fiscal year 1918 amounted to only \$124,000,000 as compared with \$977,000,000 in 1917 while exports were valued at \$191,000,000 compared with \$292,000,000 in 1917. Silver imports amounted to \$70,000,000 in 1918 against \$35,000,000 in 1917, and silver exports, \$1,399,000.



# The Present Status of Electric Brass Melting\*

A Survey of the Application of Electric Furnaces to the Melting of Brass and Other Copper Alloys—Advantages and Disadvantages of Different Types—Central Station Viewpoint

By H. M. ST. JOHN

ELECTRIC brass-melting has for some time past been the subject of much technical discussion, presented from various points of view. The advantages of the process have been outlined and the progress made with different furnace types have been dealt with in detail by men well qualified to speak with authority. The writer has no desire to duplicate what has already been done so thoroughly. It seems possible, however, that certain fundamental principles, upon which the success of electric melting directly depends, have hardly received, at least in public, the consideration which they deserve. It is the purpose of this paper to discuss these fundamentals, with particular attention to the bearing which they have upon electric-furnace design, and to trace the development of the various furnace types proposed for electric brass-melting, which have succeeded or failed, dependent upon the degree to which these basic principles have been recognized and followed. Finally, it is desired to emphasize the financial interest which the central station industry has in the ultimate success of the electric brass-furnace, and the importance of the part which this industry can take in directing the development of electric melting along sane and rational lines.

## THE FIELD OF ELECTRIC BRASS MELTING

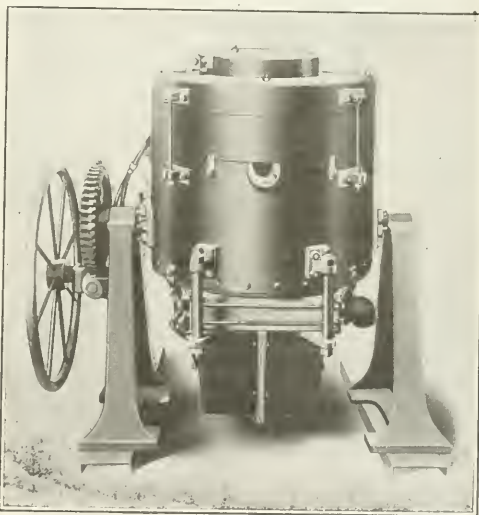
In 1914 it was estimated by Gillett<sup>†</sup> that there were, in the United States, at least 3600 plants engaged to some extent in melting brass and bronze. It was further estimated that the value of the metal annually melted by these plants was in the neighborhood of \$120,000,000, and that, of this total, the value of the metal lost beyond recovery during the melting operation was not less than \$3,000,000.

When one considers the extensive use of brass and bronze in warfare, and the enormous industrial expansion along metallurgical lines which has taken place in this country since 1914, it becomes evident that an estimate made on the basis of present conditions would name figures much larger than those stated in 1914. Even if the total tons of metal melted annually were no greater now than then, the increase in market value of the metals concerned would of itself nearly double the value of the metal produced. An avoidable waste of metal which was then considered important has ever since deserved and received, in constantly increasing degree, the attention of our metallurgists.

It has long been known that it is theoretically possible to eliminate much of this loss by the use of electric melting, particularly in the case of yellow brass and other alloys high in zinc. Most of the electric-furnace

development in the copper-alloy field has been carried out with this end in view. Metallurgically speaking, the problem is not a simple one and progress has been rather slow. Important advances have, however, been made since 1914, and the present outlook warrants a considerable degree of optimism.

Two widely different types of electric furnace are now on the market and in commercial use for melting yellow brass, one highly efficient but limited in its use to a portion of the field only, the other less efficient but otherwise more widely applicable. At least one other type of furnace has been experimentally successful and is re-



AJAX-WYATT VERTICAL-RING INDUCTION FURNACE

ported as about to enter the commercial field. Two or three additional types are being actively developed and give some promise of eventual success. So far as yellow brass is concerned, it cannot be said that an entirely satisfactory furnace has yet been produced, but the field has been partially covered, and the prospects for further advancement in the art are good.

Previous to the war the use of electric furnaces for melting copper alloys did not seem feasible except in cases where a large metal saving helped to counterbalance the higher cost of electric heat. Under present conditions the high cost and poor quality of crucibles, the high cost and shortage of important metals, the high cost and scarcity of labor, and the insistent demand for a high rate of production at any cost, are factors which combine to make electric melting profitable in

\*Read before the Ohio Electric Light Association.  
†H. W. Gillett: "Brass-furnace Practice in the United States," Bureau of Mines Bulletin No. 73, page 9 (1914).

many cases where it would previously have been unprofitable. Whether electric-furnace installations which owe their existence to these peculiar conditions will continue to show a profit when normal conditions once more prevail, is still an open question. No one can say when

conditions will again become normal, or, for that matter, what sort of conditions will be considered normal in the future. Much will depend upon the progress made in furnace design, and in operating methods, during the continued existence of the economic conditions which at present make possible the electric melting of copper alloys containing little or no zinc. The necessary progress can only be made by the combined efforts of such individuals and companies as

are now profiting, and expect to profit in the future, from the increased use of electric furnaces.

#### ADVANTAGES OF ELECTRIC MELTING

Electric heat is expansive at best, and, although it can be applied much more efficiently than heat derived from fuel, especially at high temperatures, it cannot profitably be employed except in cases where its use makes offset its added cost. The advantages which may naturally be expected to accrue from electric melting, as compared with melting in fuel-fired furnaces, are roughly as follows:

1. *Metal Saving.* The saving of metal, otherwise unavoidably lost, is the principal economic advantage which the electric furnace is required to show in the melting of copper alloys, particularly in melting yellow brass. It has been completely demonstrated that such a saving can be made in the electric furnace, by virtue of the fact that the furnace chamber can be tightly closed during the melting period, and a neutral or reducing atmosphere maintained. As we shall see later on, it does not follow that every electric furnace is capable of a favorable performance in this respect. Conditions resulting from the war have greatly accentuated certain other advantages of electric furnace operation, but in more normal times no electric furnace can hope to succeed in this field unless its use results in a saving of metal as compared with fuel-fired practice.

2. *Improved Quality.* It has been found, in most cases, that a more uniform quality of metal can be produced in the electric furnace than in fuel-fired furnaces operating under similar conditions, and that it is easier to produce an alloy of closely specified composition. In

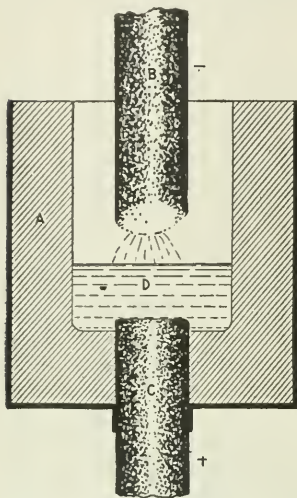
general, these advantages can be accepted as inherent in properly conducted electric furnace operation, resulting from the greatly reduced loss of volatile metals and from the elimination of contaminating combustion gases. So far as copper alloys are concerned, it is still undecided whether or not a higher quality of metal can be produced in the electric furnace, as compared with the best of fuel-fired practice. It is beyond question that high quality can be achieved more easily and certainly. The successful electric furnace must be at least as satisfactory in these respects as the best fuel-fired furnace.

3. *Exact Temperature Control.* The production of perfect castings with the least possible number of defectives depends in large degree upon the use of metal at a temperature which conforms closely with that known to be most favorable for the work in hand. The electric furnace lends itself readily to exact temperature control and thereby enjoys an important advantage.

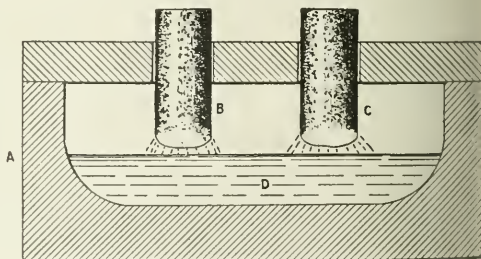
4. *Increased Production.* In general, the speed of melting is greater in electric furnaces than in fuel-fired furnaces, because of their higher operating temperature and greater efficiency. The electric furnace can also be used in larger units than is commonly the case with fuel-fired furnaces.

5. *Elimination of Crucible Cost.* The cost of crucibles is a considerable item even in normal times. Under present conditions this cost is very high. Electric furnaces which use no crucibles eliminate this expense. Large fuel-fired furnaces effect the same saving but, from a metallurgical point of view, are seldom as satisfactory as fuel-fired crucible furnaces. Electric crucible-furnaces deserve little consideration at the present time.

6. *Incidental Savings.* The operation of large units results in an economy of floor space and of labor, dependent upon the use of large electric furnaces where



DIRECT-HEATING ARC FURNACE  
From Stansfield, "The Electric Furnace"  
Courtesy The McGraw-Hill Book Co.



DIRECT HEATING SERIES-ARC FURNACE  
From Stansfield, "The Electric Furnace"  
Courtesy The McGraw-Hill Book Co.

large fuel-fired furnaces are not practicable. Increased production results in decreased overhead and interest charges per ton of metal turned out.

7. *Better Working Conditions.* More favorable conditions for the workmen, tending to increase their efficiency as well as their comfort, result when excessive heat, noise, and fumes are eliminated. The properly selected and correctly operated electric furnace is almost ideal in this respect. In installations where the reverse is true, the trouble is due to the use of an unsuitable furnace, or to careless operation, or to both of these as contributing causes.



It should not be understood that these advantages necessarily follow from the use of any electric furnace which may happen to be selected. The furnace must be of suitable type, properly designed and correctly used. A misapplied electric furnace may prove worse in almost every respect than the fuel-fired furnace which it replaces.

#### REQUIREMENTS OF ELECTRIC MELTING

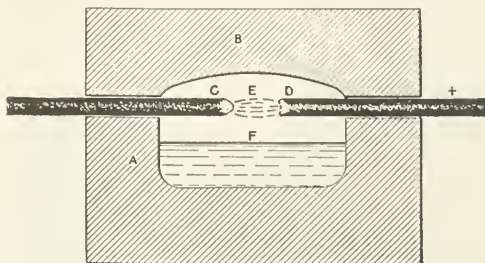
First consideration must always be given to metallurgical requirements. No electric furnace can achieve success unless it performs satisfactorily the function which is expected of it, no matter how efficient it may be nor how admirable its design may appear in other respects. Unless the design is metallurgically correct, the furnace is useless as an industrial tool.

Steel may be classed as a peculiarly "stolid" metal; it melts at a high temperature, and it may be heated as rapidly as you please during the melting operation, providing it is not exposed to contaminating elements during the process. With copper alloys the case is quite otherwise. Copper itself is somewhat volatile and oxidizes much more readily than steel, when in the molten state. Lead is somewhat volatile—more so than copper—and oxidizes very easily. Zinc is exceedingly volatile at molten-brass temperatures. All copper alloys must be treated carefully during the melting process in order that losses of metal by oxidation and volatilization may be kept at a minimum.

Yellow brass for thin castings must be poured at a temperature not far below its boiling point in order that the metal may be sufficiently fluid. At this temperature, zinc, which comprises 30 to 35 per cent of the alloy, has a tendency to vaporize rapidly. So long as the metal is contained in a tightly closed furnace chamber, which can easily be done in the electric furnace, this tendency is counter-balanced by the vapor pressure of the metal which has already been vaporized and with which the furnace atmosphere is saturated. When the furnace is opened for pouring the metal, or for any other purpose, the vapor pressure is released and further quantities of zinc will escape from the metal without restraint. If the heating has been perfectly uniform and all portions of the melt are at approximately the same temperature, the loss of zinc which ensues will constitute an unavoidable minimum. If the heating has not been uniform, some portions of the melt will be at a temperature higher than the desired pouring temperature, and such portions will lose zinc at a higher rate. If the lack of temperature uniformity is very great the loss which occurs after the furnace is opened, and during pouring, will be decidedly excessive. In fact, some portions of the metal may be so seriously overheated during melting that the high vapor pressure formed within the furnace will force considerable quantities of zinc vapor through crevices in the furnace structure. In some cases it may be practically impossible to keep the furnace chamber closed, even to a reasonable degree. Under such conditions the zinc losses are likely to be quite as serious as in fuel-fired crucible furnaces, or even more so.

What is true of yellow brass poured at a temperature near its boiling point is also true, although in less degree, of yellow brass poured at lower temperatures, and of other copper alloys. The lower the percentage of vol-

atile metal the more easily the alloy will stand up under uneven heating. But it can be accepted as an axiom of copper-alloy melting that heat must be applied to the metal as uniformly as possible, whether the alloy under treatment is a brass, a bronze, or some one of the less common alloys. If the application of heat in the furnace lacks uniformity to a serious degree, an excessive loss can only be prevented by some method of stirring



INDIRECT ARC FURNACE  
From Stansfield, "The Electric Furnace"  
Courtesy The McGraw-Hill Book Co.

the metal, and this stirring must be effected within the furnace, without opening the furnace doors.

The metal as poured from the furnace must be uniform in composition, with its various constituent metals thoroughly well mixed and alloyed. In some cases a rigidly specified composition must be closely met. The finished casting or ingot must be of a quality at least as good, with respect to strength, freedom from cracks, blowholes, etc., as that obtainable from fuel-fired crucible furnaces.

Since electric heat is more costly than that derived directly from fuel, it is important that the thermal efficiency of the electric furnace should be as high as can be obtained consistent with other requirements. A high thermal efficiency in electric melting, unless heat is generated in the metal itself, requires a high-temperature heat source, located as close as may be to the metal, under conditions which offer the least possible opposition to the flow of heat from the source to the metal. At the same time the walls of the furnace must be sufficiently thick and of high heat-insulating quality in order that heat may not be dissipated uselessly from the outer walls.

In some furnace types these requirements are directly opposed to the metallurgical requirements already considered. In such cases thermal efficiency must be sacrificed to as great a degree as may be necessary in order to satisfy the metallurgical requirements. The highest efficiency consistent with good metallurgical results should be maintained; any higher efficiency is false economy. Of course, other things being equal, the more efficient type of furnace will meet with greater success.

The electric furnace, to reap the full benefit of its economic possibilities, must operate in large units and must not use crucibles. The higher its speed of melting the better, so long as speed is not detrimental to metallurgical results.

The electrical characteristics of the furnace must be such as to make it a desirable load for the central station company or the factory power plant. Its power factor must not be abnormally low and its power fluctu-



ations must not be so violent as to endanger transformers and other electrical equipment, or to interfere with satisfactory service to other customers of the central station company who may be connected to the same power line.

It seems hardly necessary to add that the successful electric furnace must be sturdy and reliable, quite as capable of performing its function, day in and day out, under regular operating conditions, as are the best types of fuel-fired furnaces. The furnace and its adjustments should be as simple as possible, although with

through molten metal, previously melted in some other furnace.

The "pinch-effect" direct-resistance furnace was the first to utilize this principle. In this type the circuit consists of two or more vertical or inclined resistor channels in the hearth of the furnace, terminated at the lower end by electrodes, and opening at the upper end into the main portion of the metal bath, which conducts the current from one resistor channel to another. The resistor channels are so designed as to length and cross-section that the pinch phenomenon occurs in them continuously during operation. The resultant effect is a constant stream of hot metal issuing from the resistor channels, with considerable force, into the metal bath above, while colder metal flows down to take its place and is heated and ejected in its turn. Virtually all of the heat is generated in the molten metal temporarily designed for steel melting have been tried, but no new type of direct-arc furnace has been developed for this specific purpose. No furnace of this general type has ever succeeded in satisfactorily melting yellow brass, or other copper alloys containing an appreciable percentage of zinc. The high-temperature heat source in direct contact with the bath overheats the metal in its immediate vicinity and invariably causes an excessive loss of zinc.

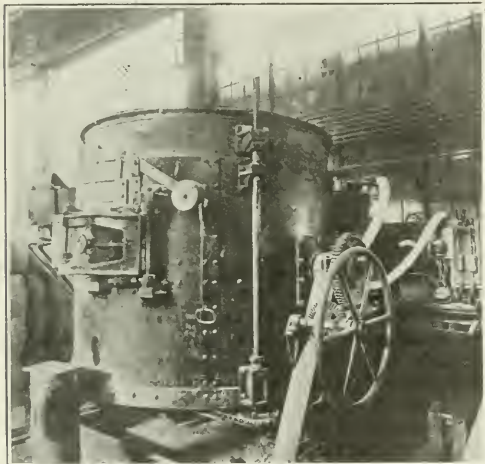
With copper alloys containing no zinc the case is somewhat different, since lack of uniformity in heating is less likely to result in serious loss. In a direct-arc furnace of small size it has been found possible to melt a copper alloy containing as much as 15 to 20 per cent lead at a loss less than that commonly experienced with the same alloy in fuel-fired crucible furnaces. In larger furnaces the greatly increased rate of heat input supplies heat to the metal, in the neighborhood of the arc, more rapidly than it can be conducted away to more distant portions; the surface of the metal becomes overheated while other parts of the bath are still much below the desired temperature.

The direct-arc furnace has the advantage of simplicity and high thermal efficiency; its design has been more highly developed and perfected than that of most other electric furnace types and, since it is so widely used in the steel industry, several furnace designs are on the market, reliable and readily available. It is very doubtful, however, if any direct-arc furnace deserves wide application for melting copper alloys. Its use is limited to only a few of the common alloys, and, if large units are employed, the metal loss, even with these alloys, is likely to be serious. Small units are more satisfactory in this respect but are subject to the disadvantages of lower efficiency, higher fixed charges, and higher operating costs per ton of metal produced.

Such direct-arc furnaces as are now in use in this field—and there are a few—hold their place by virtue of their simplicity, elimination of crucible cost, and their high rate of production, at a time when these qualities are at a premium.

#### INDIRECT-ARC FURNACES

The intensity of heat application to the metal is lessened somewhat by using an arc between two or more independent electrodes above the bath, heating the latter by direct radiation. This is the principle of the usual type of indirect-arc furnace. The arc does not come in



BAILEY INDIRECT RESISTANCE FURNACE

a large electric furnace it is permissible, and nearly always desirable, to use a higher grade of operator than would be employed to tend fuel-fired crucible furnaces.

#### FURNACE DEVELOPMENT

A great variety of electric furnace types have been proposed and tried out for melting brass. It is hardly an exaggeration to say that every known method of applying electric heat to a metal has been utilized by one or another of the various designs which have reached at least an advanced experimental stage. Some of these types have been eliminated as inherently unsuited for the purpose; some have been abandoned because of difficulties which may eventually be overcome by other investigators; others, partially successful, have apparently reached the height of their development; still others seem to possess greater possibilities of ultimate success than have yet been demonstrated.

#### DIRECT-RESISTANCE AND INDUCTION FURNACES

The most obvious method of reaching a high thermal efficiency without overheating the alloy is to generate heat in the metal itself by the passage of an electric current through it. This may be done either by means of a direct-resistance furnace, in which electrical contact with the metal is made through electrodes, or by means of an induction furnace, in which case the metal forms a complete circuit for the flow of an induced electric current, without the use of electrodes. In either case it is practically necessary to establish the circuit

direct contact with the metal and the latter forms no part of the electric circuit. It is apparent that in this type of furnace the surface of the metal is not so seriously overheated as in the direct-arc furnace, but such overheating as exists is, nevertheless, too severe to permit the use of such furnaces in melting yellow brass. The indirect-arc furnace can be used economically with alloys containing 5 to 10 per cent of zinc, possibly as high as 20 per cent, but certainly not for higher values.

The design of the indirect-arc furnace is invariably somewhat more complicated than is the case with the direct-arc furnace, and its thermal efficiency is not so high, but, in the melting of copper alloys, it can be economically used in larger units, and seems to be, in general, a more satisfactory tool for the purpose.

Several indirect-arc furnaces are now in use in this country for melting copper alloys which contain small percentages of zinc or none at all.

In a new type of indirect-arc furnace,<sup>2</sup> the metal, as soon as it becomes molten, is agitated by rocking the furnace mechanically, in order to avoid overheating of the surface layer. In this way non-uniformity of heating is largely rectified, and it is possible that alloys high in zinc can be melted without excessive loss. The furnace has received a comprehensive commercial test, and, according to report, will soon be placed on the market. This type gives considerable promise of success and should be applicable to a wide field of alloy melting.

#### INDIRECT-RESISTANCE FURNACES

Resistance furnaces which do not utilize the metal itself as an electric resistor may be grouped in three classes: (1) Those which radiate heat directly to the metal, similar in principle to the indirect-arc furnace, (2) those which radiate heat to the furnace roof and thence to the metal by reflection and secondary radiation, (3) those which feed heat to the metal by conduction through a refractory wall.

Heating by direct radiation is the most desirable of the three from the standpoint of efficiency. For this purpose it is practically necessary to support the resistor above the bath in some manner, and this has never been done successfully in furnaces of any considerable size. In small furnaces it has been possible to utilize this principle and to melt brass satisfactorily without overheating the surface of the metal to an undesirable degree, since, as compared with an arc, the resistor has a large area and operates at a much lower temperature. At the same melting speed the application of heat to the metal is more uniform but the efficiency is somewhat less.

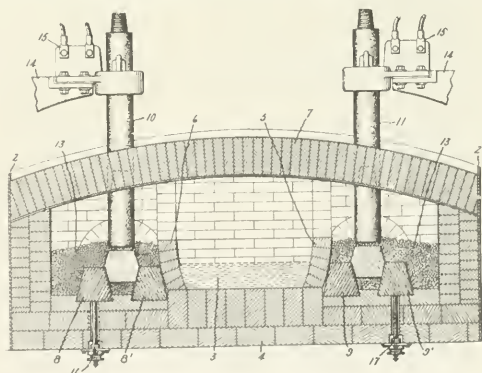
This type of furnace is applicable to yellow brass but is not in commercial use because of the mechanical difficulties involved in its construction. The possibility of its eventual use depends upon the development of a resistor material which is at once highly refractory, homogeneous, mechanically strong at high temperatures, and possessed of a fairly high electrical resistance at the working temperature of the furnace.

The second type named ranks next in the order of thermal-efficiency. In this design a refractory wall separates the resistor from the metal—although not necessarily in contact with the metal—and the major portion of the heat is radiated from the resistor to the

furnace roof, the latter acting as a secondary heat source which reflects and radiates part of the heat which it receives to the bath beneath it. The heat has to travel rather a long path and much of it is lost by the wayside. As a result, the furnace is not so efficient in principle as those previously discussed. In order to stimulate a reasonably rapid flow of heat the resistor element must be much hotter than the roof, and the roof, in turn, much hotter than the metal. Thus the possibility of a high rate of production depends upon the use of a resistor capable of operating at a temperature very much above that of the metal, even at the pouring point. The furnace roof must be exceedingly refractory and the brickwork in the immediate neighborhood of the resistor must be even more refractory than the roof. In the present state of the art these conditions are difficult to meet, and the production speed of this type of furnace is consequently somewhat limited.

The furnace, in common with other indirect resistance furnaces, contends with another disadvantage, somewhat minor in character but worth considering, which is not found in direct-resistance furnaces nor, to any great degree, in arc furnaces. The heat storage of the furnace is large and the stored heat is at a temperature higher than that of the metal. As a consequence, the temperature of the metal will continue to increase after power has been shut off. When the metal has reached its desired pouring temperature it must be poured promptly in order to avoid overheating. It is often impossible to hold the molten charge in the furnace, even for a few minutes, without serious metal loss.

This is the only form of indirect-resistance furnace which has found commercial use for melting copper alloys. In its present form, it is simple, reliable, easy to operate, and can be used on practically any alloy, for either intermittent or continuous operation. Its metal-



COMBINATION ARC AND RESISTANCE FURNACE

lurgical characteristics are excellent, with the single exception that it is somewhat difficult to secure thorough mixing, and it is especially suitable for melting alloys high in zinc. Its production rate is not rapid and it is not so efficient as the furnace types already described.

A similar type of furnace utilizes a combination of arcs and resistance elements, all radiating heat to the furnace roof, which, as in the furnace just described, serves as a secondary heat source. The use of arcs makes possible a considerably higher power input, more rapid

<sup>2</sup>H. W. Gillett and A. E. Rhoads: "A Rocking Electric Brass Furnace," *Met. & Chem.*, Vol. LXIII, No. 11 (1915), page 582.



melting, and probably a slightly more favorable efficiency, provided a sufficiently refractory roof is used. A very high efficiency cannot, however, be expected from this type of furnace. Certain difficulties in furnace design have been encountered which have so far postponed the commercial use of this furnace. It has been under test for some time, but the results obtained have not yet been made public.

The least efficient method of transferring heat from its source to the metal is to force it through a refrac-

use. It is possible that, in cases where perfection of metallurgical results is by far the most important consideration, an electric crucible-furnace can profitably be employed, but, so far as known to the writer, no commercial installation of this kind exists.

So far as thermal efficiency is concerned, the crucible furnace takes its place at the bottom of the list. Its energy consumption per ton of metal produced is about three times that of the induction furnace. One or two attempts have been made to improve the efficiency by constructing a multiple-crucible furnace, with resistor elements suitably arranged between crucibles. In this way it is possible to make a substantial gain in efficiency, but there are serious objections to this type of construction and its development has been dropped.

#### PRESENT STATUS OF ELECTRIC MELTING

We find, then, that there are four types of electric furnace in commercial use for melting copper alloys. Of these, only two are suitable for use with alloys high in zinc. One, the vertical-ring induction furnace, is of high efficiency, but somewhat limited as to its application and not sufficiently flexible for general foundry use. Within its limited range it appears to be giving very satisfactory results. The indirect-resistance, indirect-radiation furnace is less efficient and has a lower rate of production in proportion to its holding capacity, but is more flexible and better suited to general foundry use. Neither of these furnaces can be classed as altogether satisfactory but each is serving a useful purpose.

The indirect-arc furnace is in use for melting alloys which contain small percentages of zinc and those which contain no zinc at all. It is more efficient than the indirect-resistance furnace and, within its field, more flexible than the induction furnace.

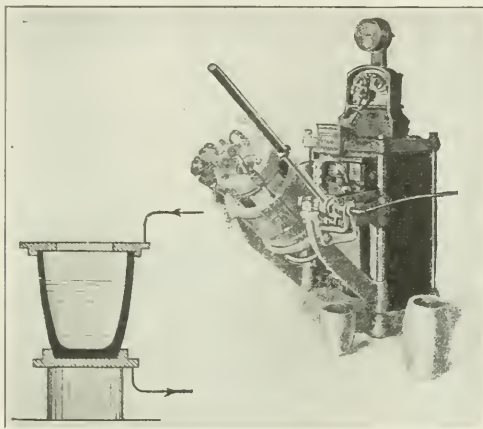
The direct-arc furnace is being used, to a limited extent, in melting copper alloys which contain no zinc. Present conditions make its use profitable in some cases, but its continued application for this purpose is not assured.

The most promising possibilities, not yet in commercial use, are, first, a form of induction furnace which will be, not only efficient, but also flexible and capable of widespread application, and, second, a form of arc furnace which will be applicable to yellow brass and other high-zinc alloys, as well as to the less sensitive alloys. Able efforts are being made to reach both of these goals. There may be some hope, eventually, of an indirect-resistance, direct-radiation furnace which will be commercially useful, but at present no steps are being taken to perfect such a type.

Electric crucible-furnaces, which are at once reliable and effective, can be built and, in fact, have found some commercial use for melting precious and semi-precious metals. In the field of copper alloys, there seems little prospect that their use will ever be profitable except, perhaps, to a limited extent, under out-of-the-ordinary conditions.

#### THE CENTRAL STATION VIEWPOINT

If all the brass and bronze produced in the United States were to be melted in electric furnaces the annual consumption of electric energy for this purpose would be in the neighborhood of 200,000,000 kilowatt hours, and the generating capacity required to supply the neces-



HELBERGER RESISTANCE FURNACE  
From Rodenhauer's "Electric Furnaces"  
Courtesy of John Wiley & Sons

tory wall, even though this wall be that of a clay-graphite crucible, a mixture which has a fairly high heat conductivity. Theoretically, the least undesirable arrangement under these conditions is to enclose the resistor in the refractory wall or to use the wall itself as a resistor. In the latter case the wall must be separated from the metal by an insulating layer to prevent short circuiting. It is not an easy matter to make this insulation permanent and this factor has been a serious source of difficulty. A resistor enclosed in a refractory wall tends to reach excessively high internal temperatures, and no material has yet been found, satisfactory in other respects, which will not destroy itself under these conditions. Another troublesome difficulty results from the ease with which most resistor materials unite chemically with the furnace refractories at high temperatures, thereby destroying both themselves and the refractories. Some two or three furnace types have been designed to make use of this principle, but they have been uniformly unsuccessful. There is at present no real activity along this line.

#### ELECTRIC CRUCIBLE-FURNACE INEFFICIENT

Finally, it is possible to melt brass in a crucible by means of resistor elements which surround but do not touch the crucible. Perhaps the most perfect results, from a metallurgical standpoint, can be obtained in this manner, but thermal efficiency is at a minimum and, in any case, the electric crucible-furnace lacks most of the secondary advantages upon which the electric brass-melting furnace must depend in part for its successful



sary power would be about 75,000 kilowatts. There is little reason to expect the complete electrification of this industry, either now or in the future, but the expansion in this field which may reasonably be predicted is sufficiently large to be interesting to the central station companies.

The central station not only has an object in promoting the satisfactory progress of this development, but has at stake interests which can only be protected occupying these channels or tubes. The main portion of the metal, occupying the furnace chamber above, is heated by contact with the hot metal, and solid metal added to the bath is melted by the same means.

The stirring action of the moving streams of metal is vigorous and the temperature of the main portion of the bath rises uniformly. There is no difficulty in restraining the vaporization of zinc, and, in fact, it may be said that the metallurgical requirements of any single alloy are almost perfectly fulfilled.

Generation of heat in the metal itself, where its presence is desired, is theoretically ideal from the standpoint of efficiency, since no part of the furnace is any hotter than the metal, and wall losses are reduced to a minimum. In this case, however, another factor tends to reduce the efficiency. The operating voltage of the furnace is necessarily very low and the current correspondingly high. The massive metallic electrodes are excellent conductors of heat and require a considerable degree of water-cooling. In this way a large quantity of heat escapes from the furnace, and the thermal efficiency is much lower than would otherwise be the case.

Considerable difficulty has also been experienced in constructing satisfactory transformers for use with such extremely low voltages and high currents as are required.

The next step in this development was the application of a similar principle to the induction furnace. This eliminated the use of electrodes and the troublesome transformers, since the furnace now served as its own transformer. In this design the resistor channels meet at their lower end, two of them forming a single V-shaped resistor, opening as before into the metal bath above. The generation of heat takes place as before in the resistor channels, and the same vigorous circulation of metal results. Whether this action is now due primarily to the pinch phenomenon, or to a motor effect resulting from the flow of current through the continuous molten resistor, is open to question. It is difficult to tell where one phenomenon leaves off and the other begins.

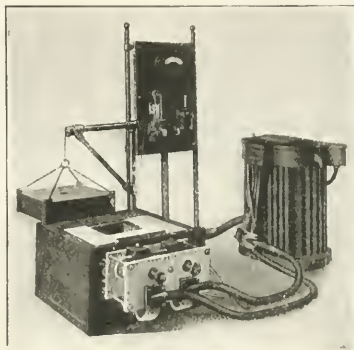
The thermal efficiency of this furnace, operating, as it does, without electrodes, is very high, probably higher than that of any other electric furnace ever tried out for copper alloy work. Its metallurgical characteristics are also excellent. It offers a perfectly steady, uniform load at a power factor which is satisfactory, at least in the relatively small sizes so far built, the largest taking a 60-kw. input and pouring 600 lb. of metal per heat. In larger sizes there might be trouble with low power factor, as is so frequently the case with large induction furnaces.

The furnace is in commercial use and is said to be giving satisfactory results. It has, however, pronounced limitations which are partly inherent in its design and partly remediable. Its small size is one disadvantage

but it is probable that somewhat larger sizes can be successfully built. It has not so far been found practicable to use the furnace with alloys high in lead, because that metal has a tendency to penetrate minute cracks in the lining of the resistor channels, causing short circuits. The remedy for this awaits the development of a lining especially suited for use with lead.

#### LIMITATIONS OF INDUCTION FURNACE

The more serious limitations of the furnace are its lack of flexibility in changing from one alloy to another and the practical necessity of operating it continuously, allowing the furnace to cool not oftener than once a week. The length and cross-section of the resistor channels are especially designed to accord with the electrical resistance—in the molten state—of the alloy which is to be used. The same resistor channels cannot be employed with another alloy of widely different resistance, which, accordingly, requires the installation of new channels of properly modified design. In changing from one alloy



HOSKINS CRUCIBLE FURNACE

to another, even if the resistance is approximately the same, it is necessary to pour the furnace clean and start with a molten charge of the new alloy, melted in another furnace.

The linings of the resistor channels stand up very well under continuous use but deteriorate rapidly under the daily heating and cooling of ten-hour day operation. This can be obviated by maintaining over night sufficient power to keep the channels filled with molten metal, which, of course, results in some addition to the cost of operation.

The limitations described tend to prevent the use of this furnace in commercial foundries, which melt a wide variety of alloys and do not work nights, but form no bar to its use in yellow-brass rolling mills, to the purposes of which it seems well suited.

#### NEW DESIGN OF INDUCTION FURNACE

There has been proposed a new design of induction furnace which would not be subject to these limitations. In this type a spark gap and an arrangement of condensers connected in series and in parallel are used in the primary circuit of the furnace, which operates at about 10,000 volts and some 15,000 to 20,000 cycles. The secondary of the furnace consists of a crucible or melting chamber with electrically conducting walls; the

metal within the crucible also carries part of the secondary current, to a minor degree when it is first charged in the form of solid pieces, to a much greater degree when it becomes molten. The primary circuit is arranged around the melting chamber and separated from it by suitable refractory and heat-insulating walls. The furnace is, in a sense, an eddy-current rather than an induction furnace, since no iron cores are used and the metal itself, lying in a circular pool, completely short circuits what, in an induction furnace, would be called the secondary circuit. This unique arrangement is made possible by the exceedingly high frequency used.

At last accounts this furnace had only been built in very small sizes, capable of pouring not more than 45 lb. of metal per heat. It is understood that the furnace is being developed energetically and it is possible that larger sizes have been built during the past six months. The design is so new and unusual that it is difficult to predict the performance of larger sizes, as to efficiency, power factor etc. There is no apparent reason why the metallurgical characteristics should not be good, and the construction of the metal-containing portion of the furnace is desirably simple. It is obviously unnecessary to use molten metal in starting the furnace. Any alloy or even nonconducting material, such as glass, can be melted without changing the furnace design. The furnace is suitable for intermittent operation and need not be kept hot overnight.

#### ARC FURNACES

Next to the methods already described the most direct way of applying heat to the metal is by means of an outside heat source in direct contact with the bath. The direct-arc furnace is the only type which utilizes this principle.

The application of direct-arc furnaces to copper alloy melting has been rather limited. One or two furnaces by a constant oversight of such features of the development as directly concern itself. For example, all furnaces are not equally satisfactory from the standpoint of economical power supply, and the power company which expects to furnish power for an electric furnace installation should, for its own sake, be familiar with the electrical and operating characteristics of the furnace.

There is an even more vital point to be considered. The central station company sells to its customers a raw material, electric energy. Electric energy must always be converted into some other form of energy by the customer before it is of the slightest use to him. Various devices are used to convert electric energy into heat, light, mechanical energy, or chemical energy. The electric furnace is such a device. These converting devices are customarily purchased, operated, and controlled by the customer. The success of his business depends in part upon their proper selection and correct use. But the success of the central station company also depends upon the proper selection and correct use of the customer's equipment, since the customer's use of the company's service cannot possibly be a satisfactory one if its method of application is faulty. This may be a matter of minor importance insofar as it concerns the use of motors and other well standardized equipment; it is a matter of great importance when it involves new electrical devices or new processes which are not well under-

stood and are, perhaps, entering the industrial world in a somewhat crude and undeveloped form.

Not all electric furnaces are good. Good electric furnaces can be misapplied. Such misapplications have been made and are now being made. Good electric furnaces, properly applied, may result in failure because of faulty operation. This, too, has happened. When such a failure occurs three parties suffer. The user of the furnace has lost some money, but he can go back to his old practice and use a fuel-fired furnace. The seller of the furnace has lost a customer, but he can find another, a few hundred miles away, who has never heard of the failure. The central station company has lost an opportunity to extend a profitable phase of its business. Every such failure becomes town talk, in an industrial sense, in the community in which it has occurred, and makes it increasingly difficult to promote the use of electric furnaces in that locality. The business of the central station company is generally limited to a relatively small territory, and its loss of possible future profits is correspondingly greater, because more concentrated, than that of the seller of electric furnaces.

The central station industry has something to gain by the successful development and use of electric furnaces, it has something to lose by their failure. It is in a position to protect this interest if it cares to do so. The central station company can, by virtue of a little effort, inform itself quite fully concerning the possibilities of electric furnace application within its territory. It can, in a similar way, make itself familiar with such requirements of its customers as have a bearing on electric furnace use. It will then have a wider knowledge than its customers of the electric furnace situation at large; it will have a more detailed knowledge of electric furnace possibilities and requirements within its territory than has the electric furnace salesman. By proper use of this knowledge and of such influence as it ought to possess in the industrial community which it serves, the central station company can promote well advised applications, prevent misapplications, point the way to correct use, discourage incorrect use, and insure the profitable development, within its field of operations, of this newest of electric load builders, the electric furnace.

Commonwealth Edison Co.,  
Chicago, Illinois.

#### Chemists Needed in War Industries

Provision has been made through an order of the Secretary of War dated May 10, 1918, by which manufacturers of material necessary to the prosecution of the war, who have lost the services of chemists through the draft, may again obtain these men for war work.

Provision has also been made whereby manufacturers threatened with the loss of their trained chemists in the present draft may retain these men. Only those chemists, however, whose services are necessary to war work, will be considered and the evidence submitted by the manufacturer must be conclusive.

Manufacturers thus affected should apply to the Industrial Relations Section of the Chemical Warfare Service, U. S. A., Unit F., Seventh and B Streets, Washington, D. C., for the regulations governing men already drafted, or the possible reclassification of men not yet called.

# Aluminium and Its Light Alloys—III

## The Constitution and Properties of Aluminium Alloys with Copper, Iron, Manganese, Nickel, Silicon and Zinc—Aluminium-Zinc Alloys Lost Tensile Strength with Increase in Temperature

By PAUL D. MERICA

### IX. INVESTIGATION OF ALLOY SERIES 1. ALUMINIUM-COPPER

THE constitution of these alloys has been studied by Gwyer (378), Carpenter and Edwards (381), Curry (382), and Guillet (384, 385). On the aluminium side of the constitution diagram a compound,  $\text{CuAl}_3$ , is formed which is partially soluble in aluminium; the exact solubility has not been determined but is undoubtedly not far from 3 per cent of copper. The eutectic of aluminium and  $\text{CuAl}$ , is at 32 per cent copper and 545 deg. C. No thermal transformations have been noticed below the eutectic temperature.

The principal research on this series of alloys is that by Carpenter and Edwards, who in addition to their studies of the constitution of this system contribute results of mechanical and corrosion tests, given below.

The tensile properties of these alloys as sand and chill cast are shown in Figs. 12 and 13. It is noted that the tensile strength of the alloy increases with the increase of copper content. The alloy containing 8 per cent of copper is one very commonly used in the alu-

of 1½ in. From this rod portions were hot rolled to 1⅜ in. diameter and drawn after annealing to 1⅜-in. diameter. From 0 to 8 per cent of copper, all of the alloys rolled well, and from 0 to 4 per cent of copper they could be drawn sound. In Fig. 14 are shown the results of the tests of 1½-in. diameter hot rolled bars. The bars rolled to 1⅜-in. diameter showed throughout a higher tensile strength than those rolled to 1½ in., amounting to from 2000 to 3000 lb. per sq.in. The bars drawn with and without annealing showed a higher tensile strength but also a smaller elongation. In Table 8 are shown the test results of an alloy containing 3.76 per cent of copper in different conditions.

TABLE VIII—TENSILE PROPERTIES OF AN ALUMINIUM-COPPER ALLOY

| (Carpenter and Edwards, 381)<br>(Alloy containing 3.76 Per Cent Cu in Different Forms) |                                     |                                |                                    |                                |
|----------------------------------------------------------------------------------------|-------------------------------------|--------------------------------|------------------------------------|--------------------------------|
|                                                                                        | Tensile Strength<br>Lb. Per Sq. In. | Yield Point<br>Lb. Per Sq. In. | Elongation<br>in 2 in.<br>Per Cent | Reduction of Area,<br>Per Cent |
| Chill casting.....                                                                     | 21,500                              | 12,100                         | 10.5                               | 21.46                          |
| 1½-in. hot rolled bar.....                                                             | 37,700                              | 20,100                         | 20.0                               | 38.21                          |
| 1½-in. hot rolled bar.....                                                             | 38,000                              | 26,000                         | 21.0                               | 49.76                          |
| 1½-in. bar drawn with annealing.....                                                   | 37,900                              | 34,600                         | 8.0                                | 21.79                          |
| 1½-in. bar cold drawn without annealing.....                                           | 44,900                              | 41,500                         | 7.5                                | 20.84                          |

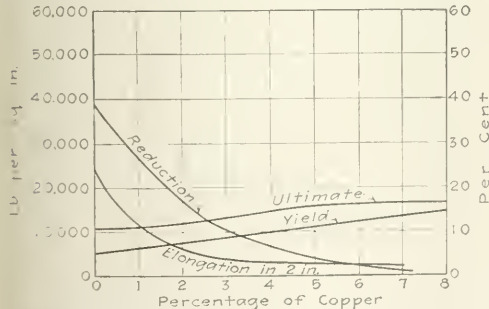


FIG. 12.—TENSILE PROPERTIES OF ALUMINIUM-COPPER SAND CAST ALLOYS (CARPENTER AND EDWARDS)

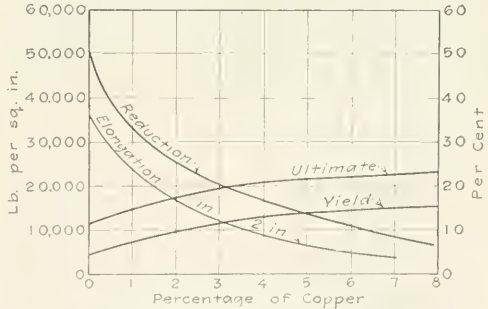


FIG. 13.—TENSILE PROPERTIES OF ALUMINIUM-COPPER CHILL CAST ALLOYS (CARPENTER AND EDWARDS)

minium casting industry to-day. Tests were made upon sand castings to ascertain the effect of heat treatment, consisting of quenching from 450 deg. C. and annealing at 450 deg. C. The alloy containing 8.08 per cent of copper showed, as sand cast, a tensile strength of 16,600 lb. per sq.in. with approximately 2 per cent elongation; as sand cast and annealed a tensile strength of 15,900 lb. per sq.in.; and as sand cast and quenched, 18,000 lb. per sq.in. Quenched alloys were consistently higher in tensile strength than the cast or cast and annealed alloys.

Ingot 3 in. in diameter and 20 in. long were heated to 400 deg. C. and rolled in round grooves to a diameter

Sheets were rolled from an ingot 6½x9½x½ in. by hot rolling at ¾ in., allowing to cool, and cold rolling to ½ in. The resulting slab was then cut into portions and the portions rolled down to different thicknesses with intermediate annealing. In Fig. 15 are shown the results of tests upon a sheet rolled to 0.05 in. in thickness. The tensile test results on these sheets are very similar to those obtained on the same alloy in the form of rolled or drawn bars. The authors draw the conclusion that there is nothing to be gained by adding more than 4 per cent of copper for rolling or forging alloy, as well as for a casting alloy. Their conclusion as regards the casting alloy is not in accord with modern practice,



which favors the use of an alloy containing 8 per cent of copper.

Plates cut from rolled sheets of copper contents varying from 0 to 5.34 per cent were exposed for 62 days to the action of both seawater and fresh water. Those exposed to fresh water were slightly corroded but gained in weight due to the coating of aluminium hydrate formed. Those exposed to the action of sea-water were

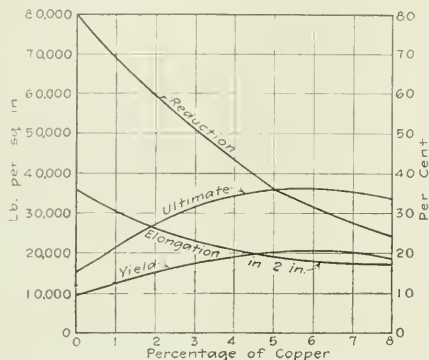


FIG. 14.—TENSILE PROPERTIES OF ALUMINIUM-COPPER ALLOYS; 1½-IN. HOT ROLLED BARS (CARPENTER AND EDWARDS)

badly corroded and pitted; the losses in weight are given below:

| Per Cent Copper | Loss of Weight in Sea-water; Lb. Per Sq. Ft. Per Month |
|-----------------|--------------------------------------------------------|
| 0.00            | 0.008                                                  |
| 0.93            | 0.008                                                  |
| 1.57            | 0.008                                                  |
| 2.36            | 0.007                                                  |
| 3.74            | 0.005                                                  |
| 4.74            | 0.004                                                  |
| 5.34            | 0.003                                                  |

The loss of weight is considerable, for the first three

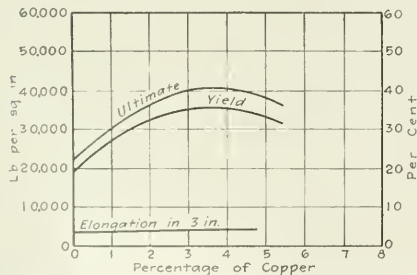


FIG. 15.—TENSILE PROPERTIES OF ALUMINIUM-COPPER ALLOYS; PLATES 0.05 IN. THICK (CARPENTER AND EDWARDS)

alloys, about 3½ times that which would be experienced by mild steel under the same conditions.

It is concluded that these alloys are not suitable for construction which will be exposed to sea-water.

## 2. ALUMINIUM-IRON

Gwyer (390) has studied the constitution of this system. On the aluminium side a compound,  $\text{FeAl}_3$ , is formed which gives a eutectic with aluminium at practically 0 per cent iron, at 649 deg. C. The compound is not appreciably soluble in aluminium.

Schirmeister below gives the results of some mechanical tests of iron-aluminium alloys.

## 3. ALUMINIUM-MAGNESIUM

Grube (402) has investigated the constitution of the aluminium-magnesium alloy series and has found that a compound,  $\text{Al}_2\text{Mg}_3$ , is formed, melting at 465 deg. C. This compound forms a eutectic with aluminium at 453 deg. C. and 35 per cent magnesium. The solubility of  $\text{Al}_2\text{Mg}_3$  in Al has never been determined; it is approximately 10 per cent.

Schirmeister (see below) has investigated the rolling and mechanical properties of this series. Up to 6 per cent magnesium the alloys may be rolled hot and cold; beyond that they are too brittle.

Lane (320) has studied the effect of small amounts of magnesium in dioxidizing and hardening sand cast 99 per cent aluminium. Averages of his results are plotted in figure 16. It is interesting to note that the effect of the magnesium makes itself evident in stages.

Alloys of this series are lighter than aluminium and have attracted on that account much interest from those seeking strong light alloys. Under the name of magnalium, alloys of this series are used for casting purposes, and are described below. This series has never become commercially important for rolling alloys. Alloys having 30 per cent and more of magnesium take a high polish and are used for mirror metal.

## 4. ALUMINIUM-MANGANESE AND ALUMINIUM-MANGANESE-COPPER

This binary system has been studied by Hindrichs (405). A compound,  $\text{MnAl}_2$  (?) is formed, giving a eutectic with aluminium at 3 to 4 per cent manganese and 650 deg. C. It is insoluble in aluminium.

Schirmeister (see below) has contributed results of tests of light manganese-aluminium alloys.

Rosenhain and Lantsberry (466) have carried out some tests on light alloys of the manganese-copper-aluminium series. Their investigation concerns itself

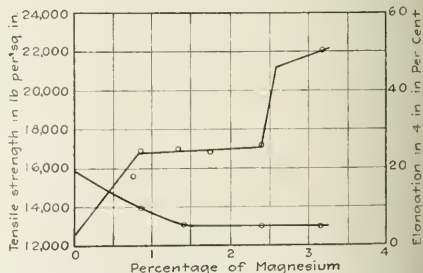


FIG. 16.—EFFECT OF MAGNESIUM ON THE TENSILE PROPERTIES OF ALUMINIUM SAND CASTINGS (LANE)

primarily with the alloys rich in copper; only a few tests were made of the strength of the alloys at the aluminium end of the diagram. Table 9 shows the results of

TABLE IX.—TENSILE PROPERTIES OF CAST ALUMINIUM-COPPER-MANGANESE ALLOYS (Rosenhain & Lantsberry, 466)

| No.  | Chemical Composition Per Cent | Copper | Manganese | Sand Cast            |                 |                              |                      | Chill Cast      |                              |                      |                 |
|------|-------------------------------|--------|-----------|----------------------|-----------------|------------------------------|----------------------|-----------------|------------------------------|----------------------|-----------------|
|      |                               |        |           | Tensile Strength Lb. | Yield Point Lb. | Elongation in 2 In. Per Cent | Tensile Strength Lb. | Yield Point Lb. | Elongation in 2 In. Per Cent | Tensile Strength Lb. | Yield Point Lb. |
| 022  | 2.15                          | 0.88   | 13,800    | 10,400               | 5               | 19,100                       | 12,400               | 6               | 6                            | 18,500               | 11,300          |
| 023  | 3.11                          | 0.57   | 15,400    | 11,200               | 4               | 18,700                       | 11,300               | 5               | 5.5                          | 18,700               | 11,300          |
| 024  | 3.28                          | 0.98   | 14,000    | 11,300               | 4               | 18,700                       | 11,300               | 5               | 5.5                          | 18,700               | 11,300          |
| 025  | 1.27                          | 2.06   | 15,300    | 12,600               | 4.7             | 13,900                       | 13,800               | 6               | 6                            | 13,900               | 13,900          |
| 026  | 2.02                          | 1.90   | 14,300    | 13,100               | 3               | 21,900                       | 13,900               | 7               | 7                            | 22,400               | 17,500          |
| 026A | 2.15                          | 1.91   | 18,100    | 14,900               | 5               | 22,400                       | 17,500               | 5               | 5                            | 22,400               | 17,500          |
| 027  | 2.89                          | 1.76   | 17,100    | 14,100               | 3.5             | 15,200                       | 13,600               | 5               | 5                            | 15,200               | 13,600          |
| 028  | 4.13                          | 1.92   | 3,200     | 3,200                | 2.5             | 18,600                       | 14,300               | 3.5             | 3.5                          | 18,600               | 14,300          |

tests of sand and chill castings of different compositions of alloys up to about 4 per cent of copper and 2 per cent of manganese. After making these tests the authors selected two alloys, Nos. 10 and 11, and tested these alloys both in the sand and chill cast condition and as rolled and drawn from ingots 3 in. in diameter. The results of these tests are shown in Table 10. Impact tests made with the Izod machine on rolled alloys showed that the No. 10 required 4.1 ft.-lb. and No. 11, 5.5 ft.-lb. of energy per unit of section in fracture.

TABLE X—THE TENSILE PROPERTIES OF ALUMINIUM-COPPER-MANGANESE ALLOYS  
(Rosenhain & Lantsberry 466)

| Alloy                                                   | Tensile Strength<br>Lb. Per Sq. In. | Yield Point<br>Lb. Per Sq. In. | Elongation<br>in 2 In.<br>Per Cent | Reduction<br>of Area<br>Per Cent |
|---------------------------------------------------------|-------------------------------------|--------------------------------|------------------------------------|----------------------------------|
| <b>ALLOY No. 10, COPPER 2.06%,<br/>MANGANESE 1.94%.</b> |                                     |                                |                                    |                                  |
| Hot rolled to $\frac{1}{8}$ in.                         | 36,700                              | 22,000                         | 18.5                               | 39.5                             |
| Hot rolled to $\frac{1}{16}$ in.                        | 38,200                              | 27,100                         | 16.0                               | 37.6                             |
| Drawn with annealing to $\frac{1}{8}$ in.               | 41,000                              | 25,000                         | 6.0                                | 11.2                             |
| Sand cast.....                                          | 19,000                              | 13,000                         | 4.0                                | .....                            |
| Chill cast.....                                         | 20,300                              | 14,300                         | 5.0                                | .....                            |
| <b>ALLOY No. 11, COPPER 2.89%,<br/>MANGANESE 0.91%.</b> |                                     |                                |                                    |                                  |
| Hot rolled to $\frac{1}{8}$ in.                         | 35,300                              | 19,700                         | 20.0                               | 32.8                             |
| Hot rolled to $\frac{1}{16}$ in.                        | 37,900                              | 28,600                         | 15.0                               | 38.0                             |
| Sand cast.....                                          | 16,700                              | 13,400                         | 5.0                                | .....                            |
| Chill cast.....                                         | 27,000                              | 16,200                         | 13.5                               | .....                            |

The authors conclude that the results on rolled and drawn bars are disappointing and that the superiority found in alloy No. 11 in the form of chill casting was not maintained in the rolled condition. The results show that these alloys have very nearly the same physical properties as the copper-aluminum alloys which were investigated by Carpenter and Edwards.

Alternating stress tests carried out on  $\frac{3}{8}$ -in. diameter rolled bars of No. 10 and No. 11 alloy gave the following values for the ranges of maximum safe stress under which these alloys would bear an unlimited number of reversals:

Alloy No. 10..... 21,000 lb. per sq.in.

Alloy No. 11..... 19,700 lb. per sq.in.

The authors also carried out some corrosion experiments on chill castings of two alloys, the results of which are found in the table below.

| Alloy                                  | Loss of Weight, Lb. Per Month<br>(30 days) |
|----------------------------------------|--------------------------------------------|
| Chill Castings of                      |                                            |
| Pure aluminum.....                     | 0.000121                                   |
| Alloy No. 10 (1.9% Mn, 2.06% Cu).....  | 0.000275                                   |
| Alloy No. 11 (0.94% Mn, 2.89% Cu)..... | 0.000128                                   |

The specimens were machined from castings and immersed for 121 days. The resistance to corrosion in sea-water of the alloys is much superior to that of aluminium. These results are contrary to usual experience with relative corrosion resistance of aluminium and its light alloys (Seligman; discussion).

Tests of resistance to corrosion by sulphuric and nitric acids of alloys of from 1 to 10 per cent Mn showed that these alloys were less resistant to the attack of these acids than pure aluminium.

## 5. ALUMINIUM-NICKEL AND ALUMINIUM-NICKEL-COPPER

The constitution of this alloy series has been studied by Gwyer (409). A compound, NiAl, is formed which forms a eutectic with aluminium at 7 per cent nickel, and 630 deg. C. This compound is not soluble in aluminium. A thermal transformation occurs at 550 deg. C. in the alloys containing from 0 to 42 per cent nickel. Reed and Greaves (456, 458) give the results of some tests of these alloys.

The authors have made a study of the properties, microstructure, and corrosion of light aluminium alloys with nickel and copper.

Some preliminary tests of the working properties of such alloys were made. Strips 35 in. in length were rolled cold with the necessary annealings, if possible to a thickness of 0.10 in. and then without further annealing to a strip having a thickness of 0.02 in. Those alloys which were perfectly sound after this treatment and did not crack or break down are comprised within the following percentages:

| Copper | Nickel |
|--------|--------|
| 0.0    | 4.0    |
| 3.5    | 4.0    |
| 2.0    | 2.0    |

A portion of each  $\frac{3}{8}$ -in. diameter rod was turned down to  $\frac{1}{8}$ -in. diameter and drawn into wire. The diameter at which the drawing had to be abandoned serves as a measure of the relative ductility of the material. Alloys within the following compositions passed through a hole of 0.033 in. in diameter without cracking or hollow drawing:

| Alloy                                  | Loss of Weight, Lb. Per Month<br>(30 days) | Nickel | Copper |
|----------------------------------------|--------------------------------------------|--------|--------|
| Chill Castings of                      |                                            |        |        |
| Pure aluminum.....                     | 0.000121                                   | 0      | 0      |
| Alloy No. 10 (1.9% Mn, 2.06% Cu).....  | 0.000275                                   | 3      | 2      |
| Alloy No. 11 (0.94% Mn, 2.89% Cu)..... | 0.000128                                   | 1      | 4      |

TABLE XI—TENSILE PROPERTIES OF ALUMINIUM-COPPER-NICKEL ALLOYS (Read and Greaves, 456, 458)

| PHYSICAL PROPERTIES |                                           |                 |                                     |                                |                              |                            |                                        |                 |                                     |                                |                              |                            |                                     |                                |                              |                            |        |        |        |      |      |      |    |
|---------------------|-------------------------------------------|-----------------|-------------------------------------|--------------------------------|------------------------------|----------------------------|----------------------------------------|-----------------|-------------------------------------|--------------------------------|------------------------------|----------------------------|-------------------------------------|--------------------------------|------------------------------|----------------------------|--------|--------|--------|------|------|------|----|
| As Chill Cast       |                                           |                 |                                     |                                | Cold Drawn Rods (3)          |                            |                                        |                 |                                     | Annealed Rods (2)              |                              |                            | Hot Rolled Rods (1)                 |                                |                              |                            |        |        |        |      |      |      |    |
| No.                 | Chemical Composition of Chill Cast Alloys |                 | Tensile Strength in Lb. Per Sq. In. | Yield Point in Lb. Per Sq. In. | Elongation in 2 In. Per Cent | Reduction of Area Per Cent | Chemical Composition of Wrought Alloys |                 | Tensile Strength in Lb. Per Sq. In. | Yield Point in Lb. Per Sq. In. | Elongation in 2 In. Per Cent | Reduction of Area Per Cent | Tensile Strength in Lb. Per Sq. In. | Yield Point in Lb. Per Sq. In. | Elongation in 2 in. Per Cent | Reduction of Area Per Cent |        |        |        |      |      |      |    |
|                     | Copper Per Cent                           | Nickel Per Cent |                                     |                                |                              |                            | Copper Per Cent                        | Nickel Per Cent |                                     |                                |                              |                            |                                     |                                |                              |                            |        |        |        |      |      |      |    |
| 23C                 | 1.11                                      |                 | 14,900                              | 5,800                          | 20.8                         | 36.2                       |                                        | 1.87            | 22,700                              | 19,700                         | 12.6                         | 36.9                       | 16,300                              | 5,600                          | 31.1                         | 55.8                       | 18,900 | 11,900 | 22.0   | 4    | 52.5 | 5    |    |
| 24C                 |                                           | 2.22            | 16,900                              | 6,500                          | 16.7                         | 22.1                       |                                        | 4.31            | 27,900                              | 22,900                         | 8.5                          | 24.0                       | 20,400                              | 9,900                          | 26.2                         | 42.1                       | 22,300 | 13,500 | 22.0   |      | 38.6 | 6    |    |
| 25C                 |                                           | 3.38            | 18,200                              | 7,400                          | 13.5                         | 21.1                       |                                        | 1.12            | 32,200                              | 26,200                         | 16.0                         | 47.7                       | 23,400                              | 8,300                          | 30.5                         | 56.6                       | 25,400 | 14,300 | 27.8   | 52.0 | 58.0 | 7    |    |
| 26C                 |                                           | 5.52            | 21,700                              | 9,000                          | 9.0                          | 11.1                       |                                        | 1.97            | 22,200                              | 30,600                         | 11.8                         | 33.1                       | 22,900                              | 6,300                          | 28.9                         | 44.7                       | 26,600 | 17,000 | 21.3   | 38.6 | 52.6 | 8    |    |
| 27C                 | 1.01                                      |                 | 18,200                              | 6,200                          | 19.1                         | 29.2                       |                                        | 2.13            | 37,400                              | 29,700                         | 7.4                          | 12.4                       | 26,300                              | 6,300                          | 27.9                         | 37.8                       | 28,600 | 17,900 | 17.8   | 29.6 | 39.6 | 9    |    |
| 28C                 | 1.00                                      | 2.18            | 18,600                              | 7,400                          | 10.0                         | 15.3                       |                                        | 2.10            | 5.33                                | 37,800                         | 31,700                       | 7.5                        | 15.3                                | 26,500                         | 9,900                        | 25.0                       | 36.3   | 31,500 | 18,160 | 16.0 | 23.6 | 6    |    |
| 29C                 | 1.03                                      | 4.03            | 23,500                              | 8,100                          | 12.1                         | 14.2                       |                                        | 4.07            | 1.12                                | 37,400                         | 31,400                       | 12.1                       | 28.8                                | 29,000                         | 7,400                        | 28.7                       | 44.3   | 32,900 | 18,400 | 20.7 | 36.9 | 36.9 | 10 |
| 30C                 | 1.02                                      | 5.51            | 24,800                              | 10,700                         | 6.1                          | 8.5                        |                                        | 4.13            | 2.16                                | 36,300                         | 31,700                       | 8.0                        | 19.3                                | 27,200                         | 8,100                        | 28.8                       | 38.9   | 30,700 | 17,900 | 17.8 | 29.6 | 39.6 | 11 |
| 11C                 | 2.04                                      |                 | 21,700                              | 7,200                          | 20.6                         | 24.6                       |                                        | 4.07            | 3.21                                | 34,100                         | 29,900                       | 2.5                        | 3.9                                 | 25,400                         | 6,300                        | 22.8                       | 28.0   | 28,700 | 17,300 | 14.5 | 18.6 | 28.6 | 12 |
| 12C                 | 1.92                                      | 2.18            | 22,600                              | 8,100                          | 11.4                         | 15.8                       |                                        | 4.08            | 4.30                                | 36,800                         | 29,600                       | 3.8                        | 6.2                                 | 25,500                         | 7,200                        | 23.5                       | 29.7   | 29,500 | 17,000 | 13.8 | 18.2 | 18.2 | 13 |
| 13C                 | 1.97                                      | 3.69            | 24,500                              | 9,000                          | 7.2                          | 9.2                        |                                        |                 |                                     |                                |                              |                            |                                     |                                |                              |                            |        |        |        |      |      |      | 14 |
| 14C                 | 1.99                                      | 2.27            | 28,600                              | 10,300                         | 5.2                          | 7.4                        |                                        |                 |                                     |                                |                              |                            |                                     |                                |                              |                            |        |        |        |      |      |      | 15 |
| 15C                 | 3.94                                      | 1.08            | 24,100                              | 9,000                          | 7.5                          | 11.7                       |                                        |                 |                                     |                                |                              |                            |                                     |                                |                              |                            |        |        |        |      |      |      | 16 |
| 16C                 | 4.05                                      | 2.02            | 23,400                              | 8,300                          | 6.1                          | 7.0                        |                                        |                 |                                     |                                |                              |                            |                                     |                                |                              |                            |        |        |        |      |      |      | 17 |
| 17C                 | 3.84                                      | 3.50            | 21,200                              | 9,900                          | 5.0                          | 9.9                        |                                        |                 |                                     |                                |                              |                            |                                     |                                |                              |                            |        |        |        |      |      |      | 18 |
| 18C                 | 4.04                                      | 4.36            | 25,200                              | 9,900                          | 4.4                          | 5.0                        |                                        |                 |                                     |                                |                              |                            |                                     |                                |                              |                            |        |        |        |      |      |      | 19 |

(1) 21 x 18-in. ingot, chill cast, heated to 400 deg. C. rolled hot to 1 in. diameter

(2) The same annealed at 450 deg. C.

(3) The same as (1) cold drawn to  $\frac{1}{8}$  in. in 2 passes

Small blocks of metal,  $1\frac{1}{2} \times 1 \times 1\frac{1}{2}$  in., were forged down hot to a thickness of  $\frac{1}{2}$  in. after heating to 450 deg. C. Those compositions which remained perfectly sound under this treatment were comprised within the following:

| Nickel | Copper |
|--------|--------|
| 7.5    | 0.0    |
| 0.0    | 5.7    |
| 2.0    | 4.0    |
| 5.0    | 2.0    |

Tests of the alloys were made as chill cast and as rolled. The chill cast ingots were 1 in. in diameter. For the rolled alloys an ingot was chill cast,  $2\frac{1}{2}$  in. in diameter by 18 in. long, weighing about  $7\frac{1}{2}$  lb. This was rolled by the British Aluminum Company to 1-in. diameter rod at about 400 deg. C. A portion of the resulting rod was cold drawn in two passes to  $\frac{3}{4}$ -in. diameter rods. Some of the 1-in. diameter hot rolled rods were annealed. The results of these tests are shown in Fig. 17 and Table XI.

It will be noticed that although the ductility of the alloys of copper-nickel-aluminum in the chill cast and in the rolled state is high, these alloys do not show a very high tensile strength. The highest tensile strength in the series is that of a cold drawn rod containing 2.1 per cent of copper and 5.3 per cent of nickel; the tensile strength of this alloy in a cold drawn state is only 37,800 lb. per sq.in.

The authors made no study of the effect of heat treatment upon rolled alloys.

Tests of the effect of annealing and of quenching on chill cast alloys containing both copper and nickel showed that both annealing and quenching lowered the

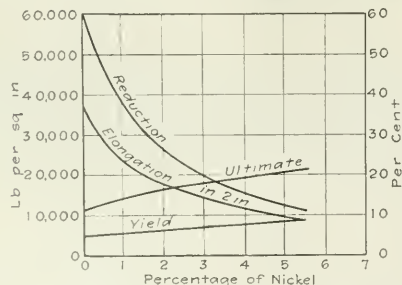


FIG. 17.—TENSILE PROPERTIES OF ALUMINIUM CHILL CAST ALLOYS (READ AND GREAVES)

tensile strength slightly (from 1000 to 2000 lb. per sq.in.) with but slight increase (1 to 1.5 per cent) in elongation.

Alternating stress tests made on the Arnold machine

TABLE XII.—CORROSION OF COLD ROLLED AND OF COLD ROLLED AND ANNEALED SHEETS OF ALUMINIUM-COPPER-NICKEL ALLOYS

| Chemical Composition   |          | —Loss of Weight in Lb. Per Sq.Ft. Per Month— |             |             |             |
|------------------------|----------|----------------------------------------------|-------------|-------------|-------------|
| Copper                 | Nickel   | Sea Water                                    |             | Fresh Water |             |
| Per Cent               | Per Cent | At treated                                   | Cold Rolled | Annealed    | Cold Rolled |
| Aluminum Same—remelted |          |                                              |             |             |             |
| 1.90                   | 0.0045   | 0.0045                                       | 0.0041      | 0.0014      | 0.0020      |
| 2.00                   | 0.0024   | 0.0024                                       | 0.0039      | 0.0014      | 0.0018      |
| 1.97                   | 0.0038   | 0.0038                                       | 0.0059      | 0.0018      | 0.0015      |
| 2.13                   | 0.0064   | 0.0064                                       | 0.0050      | 0.0011      | 0.0038      |
| 2.10                   | 0.0043   | 0.0043                                       | 0.0050      | 0.0016      | 0.0090      |
| 3.76                   | 0.0045   | 0.0045                                       | 0.0050      | 0.0023      | 0.0038      |
| 4.07                   | 0.0058   | 0.0058                                       | 0.0097      | 0.0162      | 0.0165      |
| 4.13                   | 0.0046   | 0.0046                                       | 0.0083      | 0.0169      | 0.0154      |
| 4.07                   | 0.0018   | 0.0018                                       | 0.0018      | 0.0012      | 0.0051      |
| 4.08                   | 0.0102   | 0.0102                                       | 0.0073      | 0.0154      | 0.0133      |
| ....                   | 0.0092   | 0.0092                                       | 0.0104      | 0.0030      | 0.0037      |
| ....                   | 0.0077   | 0.0077                                       | 0.0042      | 0.0045      | 0.0033      |

showed that the resistance to this test decreases with increase of both copper and nickel content.

The authors carried out corrosion tests both in sea- and in fresh-water on plates, both cold rolled and annealed,  $2 \times 1 \times 0.15$  in. Their results are given in Table 12. The results show that the alloys although inferior to pure aluminum in their resistance to corrosion are somewhat superior to other types of alloys in this respect; copper appears to accelerate corrosion more than nickel.

The authors also observed that the superiority shown by the nickel-aluminum alloys to ordinary corrosion in water was not maintained when dilute vinegar, oxalic acid, citric acid and tartaric acids were used.

The authors draw no general conclusion from their work but it is evident that the alloys of the compositions which they studied do not show a great enough strength to be considered as an alloy to be rolled into structural shapes. All the compositions were definitely inferior to duralumin.

On the other hand, the chill cast alloys look somewhat more promising and in view of the superior resistance to corrosion of the alloys of nickel and aluminium over those of copper and aluminium, may compete with the latter series in this form.

## 6. ALUMINIUM-SILICON

Fraenkel (420) has investigated the aluminium-silicon equilibrium. These metals form a simple eutectic series with the eutectic at 10 per cent (atomic) of silicon and at 580 deg. C. Silicon is not soluble in aluminium to the extent of more than approximately 0.5 per cent.

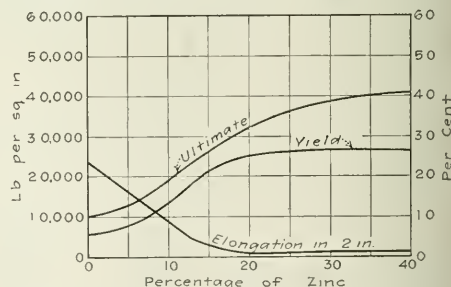


FIG. 18.—TENSILE PROPERTIES OF ALUMINIUM-ZINC SAND CAST ALLOYS (ROSENBAIN AND ARCHBUTT)

Schirmeister (see below) gives the results of some mechanical tests of aluminium-silicon alloys.

## 7. ALUMINIUM-ZINC

The constitution of this series of alloys has been studied by Lorenz and Plumbridge (436), Rosenbain (439), Shepherd (447) and others. Aluminium and zinc form a eutectiferous series, the eutectic lying at 95 per cent of zinc and 380 deg. C. A compound,  $Al_2Zn$ , is formed decomposing at 256 deg. C. Aluminium takes up approximately 40 to 20 per cent of zinc in solid solution, depending on the temperature.

The principal investigation of this alloy series is that of Rosenbain and Archbutt (438), who besides their study of the constitution of the alloy series carried out tensile, impact and alternating stress tests of cast and wrought alloys. The tensile properties were studied at



higher temperatures, and corrosion tests made on castings.

In Fig. 18 are shown the results of tensile tests of sand cast alloys of aluminium-zinc prepared by melting in an oil furnace, care being taken to keep the temperature below 800 deg. C.; the castings were 7 in. long by  $\frac{3}{8}$  in. in diameter. It is seen that the tensile strength of the alloys increases with the percentage of zinc. In Fig. 19 are shown the results of tensile tests

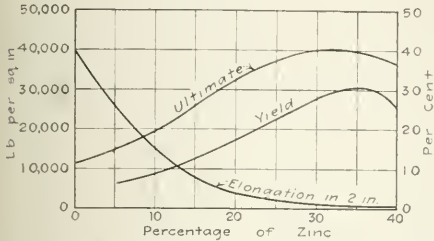


FIG. 19.—TENSILE PROPERTIES OF ALUMINIUM—ZINC CHILL CAST ALLOYS (ROSENBAIN AND ARCHBUTT)

of chill cast alloys poured into a chill mold 7 x  $\frac{3}{8}$  in. in diameter. It will be noted that the strength of such chill castings is slightly greater at all compositions than that of the sand castings; this is due primarily to the greater density of such castings.

The authors made some tests to determine whether the cast alloys of this series were subject to spontaneous disintegration. A certain number of sand cast specimens of zinc contents varying from 9 to 75 per cent were laid on one side when the alloys were originally made and tested. These were tested after an interval of fifteen months, . . . and it was found that there was no sign whatever or any disintegration, so if these alloys are subject to any aging process at all it must be of an extremely gradual character. It was found, however, that in every case there had been an increase of tensile strength, varying from 500 to 4000 lb. per sq. in., accompanied in some cases by decrease, in others by increase of elongation.

This agrees with practical experience with these alloys in that immediately after casting they are not readily machined, but "drag"; after aging for a few weeks a marked improvement in machinability occurs.

"Compression tests on both sand and chill castings showed that in general the compressive strength of these alloys is approximately proportional to their tensile strength, although the yield points in compression are also decidedly lower than the ultimate strength in tension."

In the discussion on this paper, Seligman (British Aluminium Co., Ltd.) states that the reason why composition above from 13 to 14 per cent of zinc had not hitherto been used for casting purposes was that it was the experience of the manufacturers that such alloys were sensitive to vibration and shock and hence not suitable for the motor industry.

Ingots were prepared of different compositions, 20 in. long and 3 in. in diameter. They were heated to approximately 400 deg. C. and hot rolled to  $1\frac{1}{8}$ ,  $\frac{3}{4}$  and  $\frac{1}{2}$  in. respectively. The 25 per cent zinc-aluminium alloy could fairly readily be rolled, but the 30 per cent alloy cracked considerably, even upon rolling it to  $1\frac{1}{8}$  in. in

diameter, so that 25 per cent may be looked upon as the maximum composition that can be rolled.

For some of the later series a rolling temperature of from 315 to 364 deg. C. was used with better results than at the higher temperatures. Some other experiments on the malleability of these alloys under the hammer at higher temperatures showed that the malleability increased with increase of temperature up to 400 deg. C., but that at 450 deg. C. the test specimen cracked, and at 500 deg. C. broke into coarse powder.

Samples of the  $1\frac{1}{8}$ -in. hot rolled bars were used for cold drawing experiments, the object aimed at being to reduce them by steps of  $\frac{1}{16}$  in. down to a diameter of  $\frac{1}{8}$  in. Compositions up to 15 per cent stood this cold drawing well. Above that the samples either drew hollow or broke.

The 15 and 20 per cent alloys were cast into slabs measuring  $13\frac{1}{2} \times 10\frac{1}{2} \times \frac{1}{2}$  in., heated to 400 deg. C., cooled to 300 deg. C., hot rolled to 0.13 in., annealed at 400 deg. C. and cold rolled to 0.7 in. The 15 per cent alloy behaved satisfactorily under this treatment. The 20 per cent alloy exhibited a small amount of cracking at the edge of the sheet, a defect which may have arisen from roughness of the original casting.

Fig. 20 shows the results of tests of hot rolled bars  $1\frac{1}{8}$  in. in diameter. These alloys exhibited a well-defined yield point accompanied by a sharp drop of the beam of the testing machine, similar to that found in the testing of mild steel. Similar curve series were obtained showing the results of tensile tests of hot rolled bars,  $\frac{3}{8}$  in. and  $\frac{1}{2}$  in. in diameter. The results of the former series are shown in Fig. 21. The curious fact is definitely ascertained that the alloys containing more than 15 per cent of zinc appear to deteriorate when a large amount of work is put upon them. It is seen that

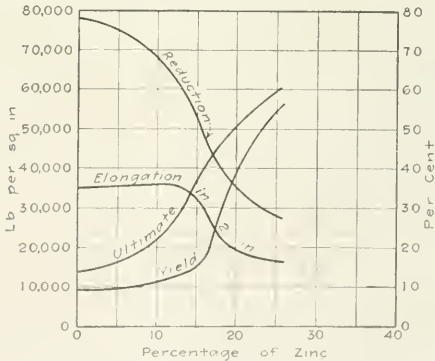


FIG. 20.—TENSILE PROPERTIES OF ALUMINIUM—ZINC ALLOYS;  $1\frac{1}{8}$ -IN. HOT ROLLED BAR (ROSENBAIN AND ARCHBUTT)

although for compositions below 15 per cent of zinc the strength of the  $\frac{3}{8}$ -in. diameter rod is higher, as might be naturally expected, than that of the  $1\frac{1}{8}$ -in. diameter rod, above that percentage the reverse is true.

A study of the tensile strength of hot rolled and annealed bars shows that for compositions between 13 and 20 per cent the application of work upon the alloys appears to have beneficial effect, which is not entirely removed by annealing. The results on one series are shown in Fig. 21. In considering the strength of cold

drawn bars drawn to  $\frac{13}{16}$ -in. diameter from the hot rolled  $\frac{1}{2}$ -in. diameter rods, it is most remarkable that the ultimate strength of the cold drawn bars is very little higher than that of the original hot rolled bars from which they were drawn; it is noted that the alloys higher in zinc (above 15 per cent) show a lower ultimate strength in the cold drawn than in the hot rolled state.

Tests made on wire, 0.128 in. in diameter, as cold drawn, show that the strength of such wire is consider-

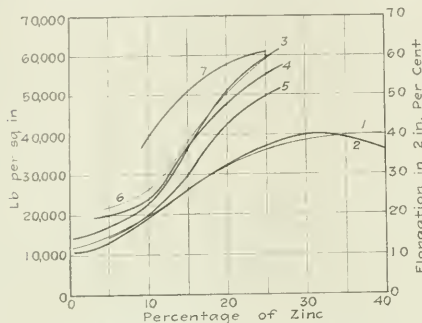


FIG. 21.—TENSILE PROPERTIES OF ALUMINIUM—ZINC ALLOYS (ROSENBAIN AND ARCHBUTT)

ably above that of any other form of the same material until a composition of 20 per cent of zinc is reached; thereafter the strength of the wire is less than that of the original  $\frac{1}{2}$ -in. hot rolled bars.

"We thus arrive at the very remarkable result that no amount of further work, whether applied to the metal when hot or cold, increases the tensile strength of the 25 per cent alloy beyond that which is attained in the form of  $\frac{1}{2}$ -in. hot rolled bars, the only marked effect of cold work being to bring about some reduction in the ductility of the alloy."

The tensile strengths of the two compositions rolled out into sheet 0.07 in. in thickness were very nearly the same as those obtained on bars, drawn with annealing as shown below:

Fifteen per cent alloy sheet, as rolled and tested longitudinally—tensile strength 47,000 lb. per sq.in.; elongation 1.5 per cent in 2 in.

Twenty per cent alloy sheet, similarly—tensile strength 50,500 lb. per sq.in.; elongation 0.5 per cent in 2 in.

After annealing at 400 deg. C., these two alloys showed 33,000 and 43,000 lb. per sq.in. tensile strength, and 24 and 10 per cent elongation, respectively.

Figs. 20 and 21 show the specific tenacity, the tensile strength divided by the density, of sand cast and hot rolled aluminium-zinc alloys and of hot rolled aluminium-copper alloys, the latter being taken from the data by Carpenter and Edwards. It will be noted that the aluminium-zinc alloy of 20 per cent shows a greater strength per unit mass than the highest strength alloy recorded by Carpenter and Edwards for the light aluminium-copper alloys.

Alternating stress tests carried out with alternations of direct stress on specimens cut from  $\frac{1}{2}$ -in. diameter hot rolled bars gave the following results:

| Per Cent Zinc | Maximum Safe Range of Stress, Lb. Per Sq. In. <sup>1</sup> |
|---------------|------------------------------------------------------------|
| 5             | 11,200                                                     |
| 9             | 15,000                                                     |
| 11            | 19,200                                                     |
| 17            | 22,400                                                     |
| 26            | 26,900                                                     |

<sup>1</sup> Giving about 1,000,000 reversals to rupture.

Impact tests carried out on the Izod machine gave the following results:

| Per Cent Zinc | Ft. Lb. Per Sq. In. Absorbed in Rupture |
|---------------|-----------------------------------------|
| 5             | 3.9                                     |
| 9             | 4.3                                     |
| 13            | 5.4                                     |
| 15            | 5.8                                     |
| 17            | 5.75                                    |
| 20            | 5.8                                     |
| 26            | 4.1                                     |

Tensile tests were carried out at higher temperature on several of the alloys. Some of the results are given in Table 13 below. Determinations made of the coefficient of thermal expansion between 0 and 18 deg. C.

TABLE XIII.—TENSILE PROPERTIES OF ZINC-ALUMINIUM ALLOYS IN FORM OF  $\frac{1}{2}$ -IN. ROLLED BARS AT HIGHER TEMPERATURES (Rosenbain & Archbutt, 438)

| Temp. Deg. C.     | Tensile Properties                    |                                  | Elongation<br>in 2 In.<br>Per Cent |
|-------------------|---------------------------------------|----------------------------------|------------------------------------|
|                   | Tensile Strength<br>Lb. Per<br>Sq.In. | Yield Point<br>Lb. Per<br>Sq.In. |                                    |
| Alloy of 13% Zinc |                                       |                                  |                                    |
| 18                | 32,100                                | 15,700                           | 31                                 |
| 50                | 28,500                                | 18,350                           | 30                                 |
| 75                | 24,000                                | 17,350                           | 29                                 |
| 100               | 20,650                                | 15,200                           | 33                                 |
| 150               | 16,000                                | 13,600                           | 34                                 |
| 200               | 11,900                                | 11,100                           | 48                                 |
| Alloy of 25% Zinc |                                       |                                  |                                    |
| 18                | 55,600                                | 44,300                           | 20                                 |
| 50                | 50,800                                | 40,100                           | 21                                 |
| 75                | 45,700                                | 34,400                           | 21                                 |
| 100               | 41,000                                | 33,200                           | 21                                 |
| 150               | 35,300                                | 30,200                           | 19                                 |
| 200               | 24,600                                | 21,800                           | 18                                 |

of these alloys in the form of  $\frac{13}{16}$ -in. diameter rolled bars yielded the following values:

| Per Cent Zinc                | Coefficient of Thermal Expansion |
|------------------------------|----------------------------------|
| 5                            | 0.000227                         |
| 15                           | 0.000231                         |
| 20 ( $\frac{1}{2}$ -in. bar) | 0.000234                         |

Sand and chill castings  $3 \times 4 \times \frac{3}{8}$  in. were machined and exposed for 521 days to the action of sea-water. The losses in weight were measured and are given in the table below:

| Per Cent Zinc | Corrosion of Zinc-Aluminium Alloy Castings |          |  | Month Castings in Sand |
|---------------|--------------------------------------------|----------|--|------------------------|
|               | Loss of Weight in Lb. Per Sq. In.          | Per Cent |  |                        |
| 5             | 0.0012                                     |          |  | 0.0054                 |
| 9             | 0.0017                                     |          |  | 0.0092                 |
| 15            | 0.0018                                     |          |  | 0.0062                 |
|               | 0.0023                                     |          |  | 0.0145                 |

The sand castings were thus superior to the chill castings in this respect.

In the appendix to this report the authors describe an alloy consisting of 25 per cent of zinc, 3 per cent of copper and 62 per cent of aluminium. This alloy shows a tensile strength of about 41,000 lb. and 45,000 lb. in the sand and chill cast condition, respectively. The rolling of this alloy presents considerable difficulty but if careful temperature control is exercised it can be hot rolled. This alloy gave a tensile strength, in the form of  $\frac{1}{2}$ -in. hot rolled bar, of 71,000 lb. per sq.in., a yield point of 61,000 lb. per sq.in. and an elongation in 1 in. of 21 per cent. The specific gravity of this alloy is 3.29.

Summarizing the work of these investigators on the physical properties at ordinary temperatures, the following points may be noted:

1. It has been found possible to roll out into bars and even to draw into wire an alloy containing as much as 26 per cent of zinc. This alloy attains its maximum tensile strength when in the condition of hot rolled bars  $\frac{1}{2}$  in. in diameter, the maximum strength being 62,000 lb. per sq.in. This alloy has a density of 3.24 when hot rolled.

2. Further rolling down of this alloy does not improve, but impairs, the tensile properties of the material.

3. Both the binary and ternary alloys referred to differ from the majority of non-ferrous alloys in the fact that in the rolled condition they exhibit a definite and well-marked yield point similar to that of mild steel.

4. A great defect of this group of alloys is their great sensitiveness to rise of temperature in relation to their tensile strength. Thus the alloy containing 25 per cent of zinc loses 33 per cent of its tensile strength (at 20 deg. C.) when the temperature is raised to 100 deg. C. The highest tensile strength of the cast alloys determined was 42,000 lb. per sq.in. for an alloy containing 50 per cent of zinc; the highest for the wrought alloys was that of the 1½-in. hot rolled bars of 26 per cent zinc content and having a tensile strength of 62,000 lb. per sq.in., a yield point of 56,000 lb. per sq.in. and an elongation of 16.5 per cent in 3 in.

5. Tests made of the resistance of these alloys to alternation of direct stress gave a series of results for the safe range of alternating stresses which lies considerably below that of the static elastic limits. The 25 per cent alloy showed a safe range of 27,000 lb. per sq.in. Single-blow impact tests made on the Izod machine showed that the work absorbed by fracture reaches a maximum for a zinc content lying between 15 and 20 per cent; this, for an alloy containing 15 per cent of zinc, is 5.8 ft.lb. Under Prof. Arnold's alternate bending tests the endurance of the alloys falls rapidly with the increase of zinc content.

## Organizing Research Work on a National Scale

THE proposal has been many times made that the work of scientific and technical research, now carried on independently by a multitude of institutions and individuals, should be organized on a national scale. Such an organization, could it be effected, would make unnecessary a vast amount of needless duplication of work. It would further be possible, by concentrating research workers on a particular task, to make much more rapid progress; and by giving the results of successful research greater prestige and standing, it would be possible to secure the adoption of new developments in practical work to a much greater extent than at present. The magnitude of the task of controlling and coördinating the research work of the entire country is such, however, that no serious attempt to do this has ever been undertaken until the war brought the need and opportunity home.

Two years ago President Wilson accepted an offer by the National Academy of Sciences to undertake the organization of the scientific resources and research facilities of the country. The National Research Council was organized, in accordance with this offer, a year in advance of this country's actual declaration of war, and it was officially recognized by the Council of National Defense and arranged to serve during the war as a department of that body early in 1917.

While the National Academy of Sciences, from which the National Research Council sprung, deals only with so-called "pure" science, it was recognized from the outset that the business of the Council was to pro-

mote research which aimed at definite, practical results.

The Executive Order of President Wilson, issued on May 11, recognized the work which has already been accomplished by the Council and ordered the coöperation with it of the scientific and technical branches of the Government. The practical nature of the Council's work was attested at the outset by the fact that its first financial support came from the Engineering Foundation; and is attested now by the fact that Governmental appropriations to the amount of \$270,000 have been made to finance special branches.

The work accomplished by the Council and its organization and plans were the subject of an address by the Council's Chairman, Dr. George Ellery Hale, delivered on May 28 before a joint meeting of the National Engineering Societies in New York City.

As much of the research directed by the Council relates to apparatus useful in the war, detailed statements concerning such work cannot be made public. It can be said, however, that among the problems with which the Council is dealing are processes for making nitrates, the manufacture of optical glass, materials conveniently located for highway construction along the Atlantic coast, methods of combating the submarine, the development of body armor, range finders, location of enemy heavy artillery by sound, psychological tests of recruits. These are but samples at random of the numerous fields in which committees of the Council are at work.

Dr. Hale, in his address, emphasized that the Council recognizes the great value of individual initiative and direction. It will aim to coöperate with and aid the individual worker and not to supersede him. A statement of Dr. Hale's which won hearty applause from his audience was the following:

"It should be said here, once for all, that the policy of the National Research Council has been from the outset invariably to recommend the immediate development and utilization for military and naval purposes of the best devices or methods known at the time, with the understanding that research for the purposes of improving such devices should not retard production demanded to meet pressing military needs."

In the special work of coöperating with existing research agencies, a census has been made under direction of Dr. S. W. Stratton, Chief of the Bureau of Standards, of the research workers and facilities in the universities, manufacturing plants, Federal Government bureaus, commercial testing laboratories, etc., throughout the United States. Another committee, of which Dr. John C. Merriam of the University of California is Chairman, has secured the organization of local research committees in 72 universities and colleges to coöperate with the National Council and in many cases with local industries.

There has also been organized with the approval and coöperation of the Secretaries of War and the Navy, a committee to interchange technical information and the results of research work with the authorities of Great Britain and France. This committee has offices in Paris, London and Washington. Dr. W. F. Durand represents the committee in Paris and Dr. H. A. Bumstead in London. The Council of National Defense has provided funds to the amount of \$38,400 for this committee's work for the current year.



## Synopsis of Recent Chemical and Metallurgical Literature

**A New Illuminator.**—The travel of the source of light in an ordinary arc, its flicker, poor color distribution and need of constant adjustment when used as a mode of illumination for microscopic, photographic, or projection work may apparently be obviated by the substitution of gas-filled lamps, according to a description published in *Electrical World* by R. P. BURROWS and J. T. CALDWELL, of the Engineering Department of the National Lamp Works of the General Electric Co. The

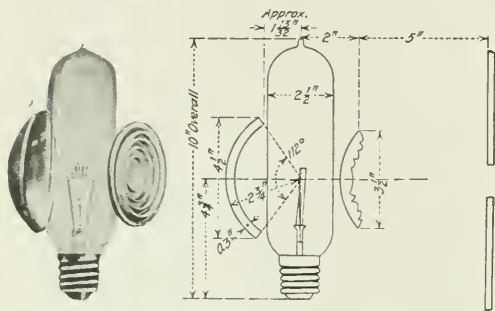


FIG. 1.—RELATIVE POSITIONS OF GAS-FILLED LAMP, MIRROR AND CONDENSER FOR PROJECTION PURPOSES

inherent limitation of the filament lamp, that is, the relatively low intrinsic brilliancy of the source has been limited by the life of the filament—the higher the temperature the shorter the life and the greater the candle power emitted per unit area of filament; and second, limited by the diameter of the filament—in general the greater the diameter of the filament the higher the operating temperature for the same life. With gas-filled lamps the brilliancy is limited to about one-fourth that of a good direct-current arc, so the success with which

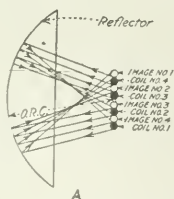


FIG. 2.—IMAGE OF FILAMENT FALLS BETWEEN COILS GIVING SOLID PLANE OF LIGHT

the light is projected depends upon the utilization of the light. The optical properties of the condensing lens evidently limits the effective size of the light source available. For this reason the "monoplane" filament has been developed, and is so arranged that all of the coils are in one plane. This construction allows most of the filament to come within the focus area of the lens system. The light from the rear portion of the filament is gathered and redirected as useful light by a spherical mirror (see Fig. 1). As shown in Fig. 2 images from the filament can be made to fall at points

between the filament coils, which gives a solid plane of light as photographed in Fig. 3. It may readily be seen that if a large bulb were to be used to inclose the filament, advantage could not be taken of the short-focus condensing lens (a prismatic lens of the Fresnel type with a 76-deg. solid angle is used); consequently it is necessary to use a bulb of as small a diameter as is practically possible. This bulb is tubular and of such length that the fine particles given off by the filament are carried upward by the hot gas and deposited on a portion of the bulb well out of the zone of useful light.

In obtaining concentration of filament it is necessary to get as high a wattage and filament brilliancy as possible for the size of light source previously determined. This can be most easily accomplished by the use of a large diameter wire, or, in other words, through the

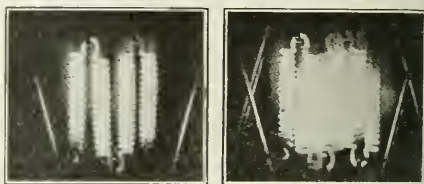


FIG. 3.—FILAMENT ALONE AND WITH IMAGE BETWEEN COILS

use of a high-current, low-voltage lamp. This is objectionable from one standpoint, in that it cannot be used on regular lighting circuits.

A transformer has been developed which can be used on 110- to 120-volt and 220-volt alternating-current circuits. This transformer includes a variable resistance, or a reactance, in the primary circuit to take care of the variations in line voltage, thus enabling the operator to maintain the normal current on the lamp. An ammeter is placed in the secondary circuit of the transformer, and a four-point starting switch is included in some equipments. This switch eliminates the possibility of a rush of current through the cold lamp when the current is first applied, for the connections are such that the current is gradually increased as the switch is thrown in.

**Strength of Oxyacetylene Welds.**—In Bulletin 98, University of Illinois, Prof. H. F. MOORE describes the results of tests performed on oxyacetylene welded joints in mild steel plates. The joints were made by skilled workmen, and should therefore be regarded as better than the joints made in ordinary welding shops. The static tension tests showed a joint efficiency of 100 per cent in plates one-half inch thick or less, decreasing with thicker plates. The joints were strengthened by working after welding, but were weakened by annealing at 800 deg. C. The efficiency of the material is always less than the efficiency of the joint, indicating the necessity of building up the weld to a thickness greater than that of the plate. Alternating stress tests follow in a general way the results given by static testing. Under impact the joints are decidedly weaker than the original material; for points welded with no subsequent treatment the strength under impact is about half that of the plate. If the weld is worked while hot the impact resisting qualities are slightly improved, while annealing at 800 deg. C. has little effect.

**Gases, Oxides and Blowholes in Admiralty Bronze.**—Prof. H. C. H. CARPENTER and Miss C. F. ELAM have experimented in the foundry of Mr. J. Dewrance, originator of this alloy, and presented their findings before the March, 1918, meeting of the Institute of Metals (British). They cast 3½-inch square ingots, 6 inches long at various temperatures determined by a thermocouple in the crucible at the time of pouring. For examination, the ingots were cut in half and machined in a special way to obviate the use of etching reagents, which would tend to increase the size of blowholes and other physical defects. A cut of 0.01 inch depth is taken with a feed of 0.01 inch with a very sharp square-pointed tool 0.01 inch wide.

They find that unsoundness was always associated with high temperature of pouring, irrespective of the kind of copper used—sand cast ingots showed a few large holes, while chill casting developed a multitude of minute ones. By alternately pouring from about 1400 deg. C. and allowing the metal to cool in the crucible to 1225 deg., the same metal is rendered alternately unsound and sound. The actual casting operation, therefore, provided the temperature is sufficiently high, is the deciding factor in producing sound ingots, and KARR and RAWDON's conclusions in *Technologic Papers* of the Bureau of Standards, No. 59, that the best results could be obtained by pouring within the range of 1120 and 1270 deg. C. is confirmed in general. Melting and casting *in vacuo* is uncommercial, and would not eliminate all the gas introduced with the cold metal. Holding the melting furnace at 1270 deg. is impracticable owing to the reduction in the speed of melting. The action of scavengers and deoxidizers is still uncertain. The best way is to measure the temperature of each crucible before pouring by proper optical pyrometers—practice

purities, much of their quantity being skimmed off the melt before pouring. It is very difficult to distinguish between tin and zinc oxides. Ferric chloride and hydrochloric acid will dissolve the zinc oxide, but will not attack the other.

The authors conducted many experiments to determine the composition of the gases filling the blowholes (evidently reducing in nature by the brightness of the cavity walls). Their results were somewhat variable. The small volume of gases obtainable was given off very



FIG. 3.—OXIDE INCLUSION, UNETCHED; x 500



FIG. 4.—OXIDE FILMS, UNETCHED; x 500

slowly, was of complex nature approximating the furnace atmosphere, and varied in composition depending upon the method of collection. If the gas is removed as quickly as it comes off, it has a smaller volume, its chief characteristics being a large percentage of sulphur dioxide and hydrogen sulphide and a small percentage of hydrogen; if, on the other hand the gas is removed slowly or heated for a long time in contact with the hot tube and metal, the volume is larger than in the former case. There is then a large percentage of hydrogen, and the sulphur dioxide and hydrogen sulphide are either low or entirely absent. The zinc is largely responsible for this change, as there is much less difference in the gases collected in the two ways from pure furnace-refined copper. Zinc may act in this manner by lowering the solubility of the gases in the alloy, or by volatilizing *in vacuo*, reacting with the sulphur forming zinc sulphide which forthwith condenses on the inside of the tube. There is no outstanding difference between the gases collected from sound and unsound castings which would account for the presence or absence of the blowholes. It cannot be concluded from their experiments that there is any gas present in the metal poured too hot that is not in sound metal, nor does it appear that there is a larger volume of any one gas or gases present in the one than in the other. Experiment showed that there is a drop of about 100 deg. C. in the temperature of the metal in passing from the crucible to the mold. The explanation appearing most probable is based on the fact which they have established that this mixture of gases can exist in more than one form, each possessing its characteristic volume and composition. The sudden change in temperature of the alloy on pouring is sufficient to cause a reaction or a decomposition of certain of the gases, with the formation of another gas mixture with a relatively large volume which is insoluble in the alloy.



FIG. 1.—OXIDE INCLUSION, CONSISTING OF TWO OXIDES, UNETCHED; x 500



FIG. 2.—OXIDE INCLUSION, UNETCHED; x 500

of this method should be easy in comparison with that of progressive steel makers who try to control the temperature of casting to within 20 deg. at 1600 deg. C.

Figs. 1 to 4 show various inclusions of oxides found on microscopic examination. These are often associated with the delta copper-tin constituent—the light portion of Fig. 2. The rhombohedral inclusions of Fig. 3 occurred in metal often remelted and containing little or no zinc. One would expect the copper oxide formed in melting to be reduced by zinc and tin when they are added; the oxides of the two latter being insoluble, collect and liquitate as mechanical im-

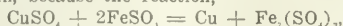
## Recent Chemical and Metallurgical Patents

**Ammonia by Hydrogenation of Nitrogen.**—The processes for the production of synthetic ammonia by the hydration of aluminium nitride and calcium cyanamide are well known commercially. MR. CARLETON ELLIS, of Montclair, N. J. (assignee, C. S. Lutkins, Rye, N. Y.), has patented a more direct process passing a mixture of nitrogen and hydrogen at high pressures and temperatures (40 atm., 500 deg. C.) in volume proportions of one to three over catalytic materials of the type of nickel-cobalt carbides whereupon a chemical reaction takes place producing synthetic ammonia. (July 23, 1918; 1,273,772.)

**Process of Producing Cyanamides.**—VICTOR THRANE, of Christiania, Norway, patents the use of the Hoffmann Ring furnace, together with the sifting of inert materials over the furnace conveyors in order to prevent the fusion of the carbides thereon during the nitridding of the calcium carbide. The conveyor moves the carbide charge countercurrent to the flow of nitrogen and is so speeded that time for completing the reaction is allowed in approaching and passing through the fired zone. The use of the inert intermediate material expedites the discharge of the conveyor. In the many installations of these furnaces in the German pottery works, sand has been universally used to protect the metal mechanical parts, it having the property of flowing readily when hot. (July 23, 1918; 1,273,690.)

**Production of Nitrogen.**—The process of removing oxygen from air by combustion with hydrogen in a gas engine and utilizing the force of the reaction in generating electromotive force for the electrolysis of water to maintain a continuous supply of hydrogen has been patented by MR. CARLO ANDREUCCI, of Rome, Italy. He has successfully practiced this process by bringing about by means of an electric spark the explosion of successive charges each of substantially 1000 liters of air (containing 209 liters of oxygen) with 418 liters of hydrogen, in the combustion cylinder of an internal combustion gas engine provided with an electric spark plug. The proportions given may be determined or regulated by operation of the throttling inlet valves, one for air and the other for hydrogen. About 336 grams of water and 778.3 liters of nitrogen mixed with oxides of carbon, argon, etc., are obtained per 1000 liters of air. (July 9, 1918; 1,272,181.)

**Depolarization by Sulphur Dioxide.**—F. E. STUETZ, of London, England, notes that it is undesirable to utilize the ferrous salts contained in solutions from leaching copper ores as a depolarizer when electrolyzing them, because the reaction,



is reversible, the ferric sulphate formed corroding the cathode copper, thus lowering the ampere efficiency. Using  $\text{SO}_2$  as a depolarizer prevents this effect, requires a lower cell voltage, and generates sulphuric acid. He therefore specifies the use of solutions properly reduced, containing little or no ferric iron, and saturated with

$\text{SO}_2$ . Proper cell conditions require constant circulation, a low current density (13 amps. per square foot) and a temperature of 49 to 53 deg. C. Liquid sulphur dioxide, readily made from smelter gases, is gasified, and introduced to the electrolytic tanks under a pressure of two to four atmospheres with a sufficient quantity of steam to maintain the temperature of the electrolyte in the required range. These gases enter through a grid of perforated lead pipes laid on the floor of the tanks, and placed in such a manner that a stream of bubbles impinges on both sides of each anode. This delivers the depolarizing agent to the exact place where it is needed, and maintains correct agitation. The steam effectually prevents the formation of crystalline growths tending to plug the small openings. The overflow from the electrolytic tanks is thus saturated with  $\text{SO}_2$ , which, if sufficiently long time is given in the leaching tanks, will reduce any ferric salts formed during that part of the cycle. (1,260,830; Mar. 26, 1918.)

**Electrode Construction.**—JAMES B. HERRESHOFF, JR., of Richmond Hill, New York, notes that the circulation of the electrolyte tends to carry small particles of impurities from the copper anode over to the cathode, where they lodge and thus contaminate the resulting deposit. It has been proposed to hang bi-polar electrodes

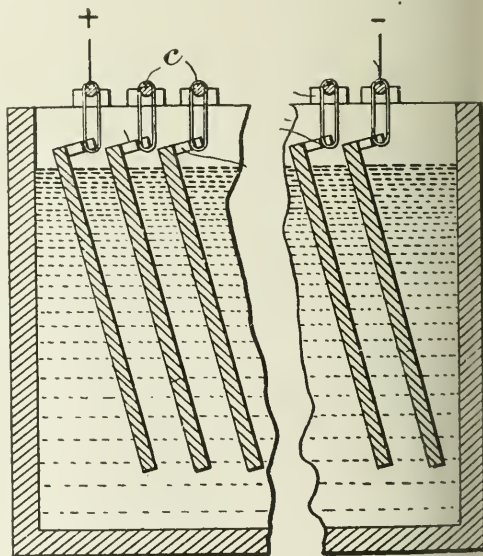


FIG. 1.

at an inclination, so that the cathode side is inclined downward, thus minimizing the tendency of any wandering slime particle to adhere. The inclination has ordinarily been effected by resting the lower end of the electrode against cross bars, which offer obstruction to the free settlement of slime, causing an accumulation of such material sufficient to short circuit portions of the cell. The inventor proposes to hang the electrodes freely in the solution at a proper and parallel inclination by casting an offset ear to the top, as shown in Fig. 1. (1,262,045; Apr. 9, 1918.)



## A Permeameter for General Magnetic Analysis

BY FRANK P. FAHY

THE writer has described<sup>1</sup> a permeameter for general magnetic testing in the use of which the difficulties formerly encountered in accurately and rapidly determining the magnetic properties of materials have been largely overcome. This apparatus calls for but one compensating adjustment and is so adapted that it may be used to simultaneously compare the properties of two specimens, one of which partakes of the character of a standard, or to measure the properties of a single specimen. The extended use of this permeameter in investigative work has disclosed that where a simultaneous comparative measurement is not required a great gain in simplicity of construction and ease of manipulation is possible without departing from the principle of operation or sacrificing accuracy. The new permeameter has no compensating adjustment and calls for no previous experience in magnetic testing on the part of the user.

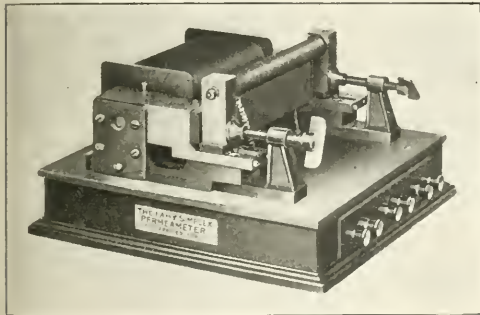


FIG. 1.—SIMPLEX PERMEAMETER

Fig. 1 shows the new permeameter in standard form as arranged to take specimens from ten inches in length upward.

### THE MAGNETIC CIRCUITS

In Figs. 2 and 3 are shown the permeameter in plan and elevation. *A* represents the base of the apparatus upon which is mounted a magnetic core of U-shape, consisting of a yoke portion *B* and core arms *C* and *C'*. In the operation of the instrument the polar faces of these core arms are bridged by the material under test. The core is mounted upon supporting members *a* of non-magnetic material which are secured to the base *A*, the core arms being fastened to *a* by bracket members *a'* and core arm extensions *a''*. The core arm extensions *a''*, which are of magnetic material, are attached respectively to the outer portions of the core arms *C* and *C'* and to the supporting members *a* and bring about magnetic contact with the edge portion of the test specimen when the latter is of solid rectangular or lamellar sheet form.

*I* and *I'* are magnetic contact shoes to the lower ends of which are attached supporting blocks of non-magnetic material *a'* which engage with slots cut in the exten-

sions *a''* and serve to permit movement of *I* and *I'* toward and away from the pole faces of the core arms *C* and *C'*. The purpose of the supporting blocks *a'* is to retain the contact shoes *I* and *I'* at a definite distance from the extensions *a''* and to prevent magnetic

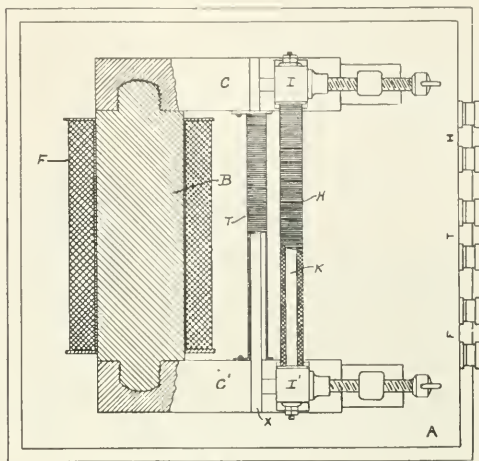


FIG. 2.—PERMEAMETER IN PLAN

contact therewith. Clamp supports *a'* of non-magnetic material are secured to the base *A* adjacent to the polar faces of the core arms *C* and *C'* and are provided with clamping screws *D*.

Upon the yoke portion *B* of the magnetic core is located a magnetizing coil *F*. A test coil *T*, within which the specimen under test is inserted, is situated at the ends of the core arms *C* and *C'*. A second test coil *H*, which is wound upon a solid non-magnetic core *K*, is affixed between the upper ends of the contact shoes

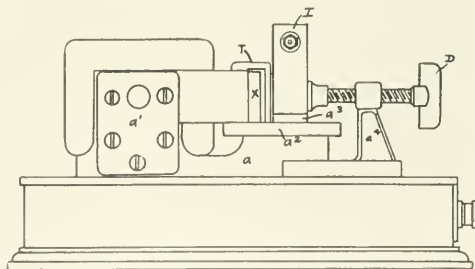


FIG. 3.—PERMEAMETER IN ELEVATION

*I* and *I'*. Fig. 4 shows diagrammatically the flux path within the core due to the magnetomotive force generated by current in the coil *F*. In practice this current is usually supplied by a storage battery. The magnetic field due to the current has the direction indicated by the arrows, or the reverse, according to the direction of flow of the current in the coil *F*.

### ELECTRICAL CONNECTIONS

Fig. 4 also shows diagrammatically the electrical connections of the permeameter. The magnetizing coil is connected to the terminals marked *F*, the test coil *T*

<sup>1</sup>Fahy, "A Permeameter for Magnetic-Mechanical Testing," *Electrical World*, Vol. 63, p. 315, 1917. See also "An Experimental Study of the Fahy Permeameter," *Scientific Paper No. 306* of the U. S. Bureau of Standards.

to the terminals marked *T* and the test coil *H* to the terminals marked *H*. The terminals *F* are connected, externally to the instrument, to a source of electromotive force *P* in series with an ammeter *O*, a controlling rheostat *RF* and a reversing switch *L*. Interposed be-

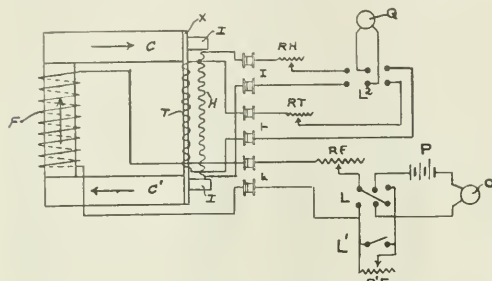


FIG. 4.—PLAN OF CIRCUITS

tween two of the points of switch *L*, as shown, is a second switch *L'* which bridges a rheostat *RF*. The terminals *T* and *H* are connected through controlling resistances *RT* and *RH* respectively to a multipoint switch *L'* so that each of these circuits may at will be connected to an indicating instrument *Q*.

This indicating instrument *Q* is a special form of galvanometer of the D'Arsonval type which is calibrated by a mutual inductance, not shown in Fig. 4. When the galvanometer is adjusted in accordance with the constants of the coils *T* and *H*, which is brought about by manipulation of the resistances *RT* and *RH* respectively, its reading indicates directly the magnetic effects operating upon the particular circuit to which it is connected.

#### BASIS OF OPERATION

In the use of the permeameter a test specimen *X* is inserted within the coil *T* and clamped in place by means of the screws *D*. The test specimen should preferably be long enough to span the outer extremities of the pole faces, and may be as much longer as desired. Comparative data may however be obtained with lengths which do not actually bridge the pole faces. The screws *D* engage with the magnetic contact shoes *I* and *I'* so that, as shown diagrammatically in Fig. 4, one face of the test material *X* makes contact at each end with a polar face of the core arms *C* and *C'*, while the opposite face makes contact with *I* or *I'*. By reason of the non-magnetic supporting blocks *a*, *I* and *I'* make magnetic contact solely with the material under test and not with any portion of the magnetic core.

The magnetic induction in the test material *X* is determined in the usual manner from the magnitude of the impulsive throw of the galvanometer which occurs when the latter is connected to the test coil *T* and the direction of flow or magnitude of the current in the magnetizing coil is changed. That is, a quantity of electricity flows through the galvanometer which corresponds in magnitude to the change in induction in the test material. When the galvanometer is connected to the coil *H* and the current in the magnetizing coil is changed in any manner, the impulsive throw of the galvanometer indicates the change in induction in the air space encircled by the coil winding *H*. This change

in induction corresponds to the change in magnetic potential existing between the ends of the test material. The average magnetic potential drop per unit length of the winding *H* is equal to the average magnetizing force to which the body *X* is subjected. Observation therefore of the throws of the galvanometer when the latter is connected in sequence to the coils *T* and *H* and the same change in current in the magnetizing coil is gone through indicates the induction and the corresponding magnetizing force.

The use of the shoes *I* and *I'*, which are of low reluctance, removes the necessity of having the ends of the coil *H* immediately in contact with the test material, which would seriously limit the practical utility of this method of measuring magnetizing force. Since the shoes are in magnetic contact with the material under test only, the magnetic potential measured is actually that operative on the specimen. Faulty contact between the test material and the magnetic core, which would cause excessive magnetomotive force drop at the polar contact faces and result in serious error in measurement if the magnetizing force were calculated from the ampere turns, knowing the constants of the magnetizing coil, which is a common method, has no appreciable effect on accuracy in the method here described. Such faulty contact may be due to the test material not being straight or having irregular or scaly surfaces. The compensating adjustments required in most permeameters are designed in large part to overcome such conditions by supplying additional magnetomotive force to offset the losses at the contact faces.

#### MANIPULATION

The test material is inserted within the coil *T* and the clamps *D* screwed up so that the material makes reasonably good contact with the polar faces of the core

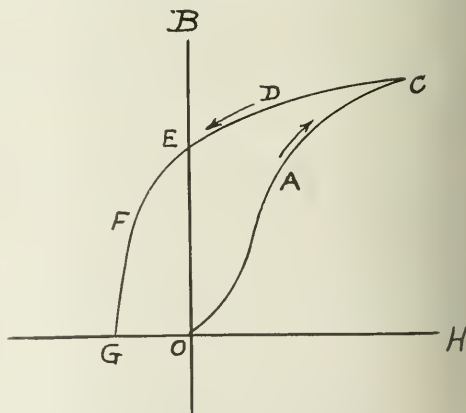


FIG. 5.—NORMAL INDUCTION CURVE

arms and with the contact shoes. The material may be in the form of a very long bar and the test confined to any region along its length.

The galvanometer is calibrated by means of a mutual inductance, and the resistances *RT* and *RH* adjusted so that when successively connected to the coils *T* and *H* in the course of a test, the readings will indicate flux density. The flux density observed when the coil *T*

is connected to the galvanometer is subject to a slight correction to obtain the actual density in the material under examination. This correction is the result of the coil  $T$ , which must necessarily be somewhat larger in cross-sectional area than the test material, encircling more flux than threads the material alone. The flux density threading the coil  $H$  indicates directly the magnetizing force.

#### DETERMINATION OF NORMAL INDUCTION

The coil  $F$  is energized and the material under test demagnetized by repeated reversals of a successively decreasing magnetizing current. During these reversals and throughout the normal induction test, the switch  $L'$  is closed so that whether switch  $L$  be closed to the right or left the same current flows through coil  $F$ . The demagnetizing operation is for the purpose of freeing the material from the effects of any previous magnetization and it is sufficient for this purpose to start the demagnetization from a current value which carries the induction beyond the point of maximum permeability, as  $A$ , Fig. 5. After reducing the induction to practically zero, the magnetizing current is increased to the value which will give the lowest induction desired for the test data. This current is then reversed several times to bring the material into a magnetically cyclic state.

To read the induction, the coil  $T$  is connected to the galvanometer by means of the switch  $L'$  and the impulsive throw noted when the current in the magnetizing coil is reversed in direction by means of the switch  $L$ . To read the corresponding magnetizing force the galvanometer is connected to the coil  $H$  and the throw noted when switch  $L$  is again reversed. Successive readings of induction and the magnetizing forces corresponding thereto may be made by increasing the current in  $F$ , by steps, up to the point of maximum induction desired. No further demagnetizing is required for values of induction higher than the initial one.

#### DETERMINATION OF HYSTERESIS

Hysteresis determinations may be made from any value of flux density reached by the material under test. As indicated above, the hysteresis, for any given material, depends upon this maximum value of flux density. In the standard tests of materials which enter into electrical apparatus where we are directly concerned with the magnetic quality of the material, this induction is usually specified as 10,000 in the case of sheet steel, and for permanent magnet material as that induction which is reached under a magnetizing force of 200. In the investigation of materials where information as to their mechanical characteristics is sought, the maximum induction employed is that corresponding to practical saturation of the material.

In determining hysteresis, the switch  $L'$  is closed and the current in coil  $F$  increased to give the proper maximum induction. Switch  $L$  is then reversed several times, being finally thrown to the right, Fig. 4. The induction is then represented by the point  $C$ , Fig. 5. If switch  $L'$  is then opened, the rheostat  $R'F$  is then interposed in the magnetizing coil circuit, and both the induction and magnetizing force fall to the values represented by, say, the point  $D$ , Fig. 5. If the gal-

vanometer is successively connected to the coils  $T$  and  $H$  while this operation is gone through, the throws of the former will indicate the changes of induction and magnetizing force resulting. Subtraction of the values represented by these changes from the values represented by the point  $C$  will establish the point  $D$ .

Except where the material under test is extremely soft, or in other words of high permeability, the determination of the point  $E$  is made, having closed switch  $L'$ , come back to the point of maximum induction and reversed several times, by opening switch  $L$  and observing the changes in induction threading the coils  $T$  and  $H$



FIG. 6.—CONTROL BOX

as above. Opening the switch  $L$  reduces the magnetizing force to practically zero. However, the test material is still subject to a very small magnetizing force, which finds its source in the residual induction of the soft iron core of the permeameter. The amount of this magnetizing force is negligible in the testing of magnet steels and tools, but where it is necessary to take it into account establishing the point  $E$  requires the application of a small magnetomotive force in the reversed direction. The procedure is then the same as that for establishing the point  $F$ , described below, the only difference being in the amount of reversed magnetizing force applied.

To establish the point  $F$ , proceed as before, magnetizing the material to the point  $C$ , reversing switch  $L$  several times and finally closing it to the left, Fig. 4. Then having opened switch  $L'$ , throw switch  $L$  to the right. This reduces the magnetizing force from the value represented by the point  $C$  to a lower value in the reverse direction. To reduce the induction to zero, that is to establish the point  $G$ , start again from the maximum induction, adjusting rheostat  $R'F$  until the change of induction indicates that the induction has finally been reduced to zero.

In general, the determination of hysteresis in practice goes only as far as the determination of the points  $E$  and  $G$ . The ordinate  $OE$ , Fig. 5, represents the residual induction, or that induction which persists under zero magnetizing force after previous magnetization. The abscissa  $OG$  represents the coercive force, or that reversed magnetizing force which is required to reduce the residual induction to zero. These values, residual induction, designated by  $B_r$ , and coercive force, designated by  $H_c$  are the two important properties with which we are concerned in the examination of steels intended



for use as permanent magnet material. These quantities are of equal importance in the testing of materials where it is desired to interpret the magnetic data in terms of structural stability.

A control box, Fig. 6, has been designed for use in connection with this permeameter which contains in compact form the switching apparatus shown diagrammatically in Fig. 5, together with the mutual inductance for calibrating the galvanometer and the adjusting resistances.

The permeameter shown in Figs. 2 and 3 is especially adapted to the measurement of the properties of materials where it is convenient to prepare samples for test. For material which is round in section special bushings may be used to insure reasonably good contact at the polar faces. The instrument may also be used in the testing of diversely shaped tools, but with some special shapes a modification of the design is called for. The control equipment external to the permeameter proper is suitable for use with any modification of the instrument which is necessary by reason of special conditions or requirements.

The test procedure outlined above under "Manipulation" is seldom gone through in its entirety and only when all of the properties of the material under examination are to be determined, as an investigative work. In routine examination the test may be confined to the determination of the induction under a given magnetizing force, or the determination of the residual induction or coercive force, or both. It will frequently be found that but a single criterion is necessary to establish the nature of the material. When either permeability or hysteresis tests are made at reasonably high values of induction, which is almost always the case, there is no necessity of initially demagnetizing the test material.

76 Church St.,  
New York City.

### Automatic Blow-Case Valve

**A**N automatic device consisting of a compound liquid check valve and air line control employed for air blowing in acid montejus has been developed by the Monarch Manufacturing Works, Inc., 3128 Emery Street, Philadelphia, Pa. Fig. 1 shows the device, which consists of two flange-like parts. The heavy dotted line indicates the bases of the ribs, the intervals between which form parts for the flow of the incharging liquid around the check and air valves. The valves sit loosely on the seat formed by the ribs. Through the lower ribs, air ports are bored.

The acid flows from the storage tank, tank car etc. through the combination check valve and air device, into the monteju. As the blow case fills with liquid, the volume occupied by the air contained becomes smaller with accompanying compression. When this counter air pressure has become equal to the liquid head, a surging escape of air takes place, which unseats the air valve and allows an influx of compressed air through the rib air ports. This pressure is sufficient to seat the valve tightly against the upper inlet *s*, shutting off the inflow of liquid and discharging the acid from the base through the open discharge line. When the charge has been blown out, the air escapes so rapidly that the fluid head pushes the valves into the lower seats, stop-

liquid. This is made possible because the inverted-cup-shaped check does not rest on the air port stopper, thus pinging the discharge of compressed air and starting a recharge of acid.

A feature of this device is the operation of the valves, which are worked in counter-current to the inflowing

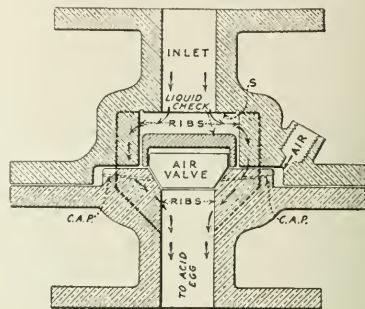


FIG. 1.—BLOW-CASE VALVE

allowing freedom for the easy upward movement of this part when the surging effect takes place. The manufacturers make this device in several sizes using all the usual materials excepting stoneware.

### All in Readiness for Chemical Exposition

More than 350 exhibitors have signed contracts to date for space at the Fourth National Exposition of Chemical Industries to be held in Grand Central Palace the week of September 23-30. This means that all of the floor space on the three available exposition floors of the building will be filled to capacity with the most interesting and varied displays relating to the chemical industry and its thousands of ramifications. When the public stops to consider that the wonderful drive now being made on the Western front is due in a large measure to the advances made in chemistry in this country since the beginning of the war, and that our chemical processes varying from munitions and poison gas to alloy steel are, like American fighters, superior to the German product, the importance of a great clearing house for the brains of this industry is at once apparent. That, in effect, is what the huge exposition is—a great get-together which affords the master minds an opportunity to meet in one place and exchange ideas in personal interview in a way that eliminates thousands of miles of railroad travel.

The fact that the United States Government is about to take over Grand Central Palace and convert it into a base hospital positively will not interfere with the holding of this exposition, which will terminate on September 30. In fact it is said that high officials of the Government considered this exposition such an important one that they would be loathe to interfere with its successful presentation. Arrangements have been made to remove the displays at the close of the exposition in ample time to suit the Government. The latest information regarding the building is that it will be remodeled to accommodate 3000 patients and will be ready December 1. The lease is for the period of the war and three months after.

## Book Reviews

**JAMES WOODHOUSE.** By Provost *Edgar Fahs Smith*. 299 pages. Price \$1.50. Philadelphia: The John C. Winston Company.

The chemical activities of James Woodhouse are of interest to all chemists, whether they have a taste for the history of the science and its literature or desire to confine their attention to bare practicalities. Dr. Smith has expended great efforts to convey an insight into the scientific character of this pioneer American chemical genius. His laboratory at the University of Pennsylvania was the forge where the weapons were wrought which conquered the phlogiston theories, then championed in this country by Joseph Priestley whose style of work is presented in his own writings on "Experiments and Observations on Different Kinds of Air." 1775, where he says: "More is owing to what we call chance . . . than to any proper design or preconceived theory in this business."

Woodhouse was not a chance chemist. He did not look for the proverbial "discovery by accident." He had a fair imagination but did not make Grecian use of it. He labored diligently in his laboratory. Whether he sought an economic use for persimmons or a national source of nitrates, he worked with a scientific procedure of almost modern characteristics. He was not a mere understudy of the European schools; and whatever may have been the motives of Dr. Benjamin Rush in lending his influence in having Woodhouse appointed to the chair of chemistry at Pennsylvania, the name of this successor to Franklin in the scientific circles of our first capitol will be mentioned by chemists with pride.

\* \* \*

**SULPHURIC ACID HANDBOOK.** By *Thomas J. Sullivan*. Pages 240. Price \$2.50. New York: McGraw-Hill Book Company, Inc.

This is the most up-to-date handbook of the numerical data on sulphuric acid. It treats of its subject from the gaging of the volume in vertical or bumped horizontal cylindrical tanks right through the laboratory gravity and temperature determinations and calculations, and finally ends with splendid data on iron and lead acid-proof pipes and fittings.

The recognized standard tables in use in the United States on the Baumé hydrometer scales and the acid gravities etc. (Ferguson and Talbot determinations) adopted by the Manufacturing Chemists' Association of the United States are given. Most of the data on the manufacture of acid, on sulphur, sulphur dioxide gas, nitric and nitrous acid, arsenic, selenium etc. are sufficiently covered for practical application in the plant. All chemists having anything to do with the mineral acids will find their requirements best taken care of by consulting this convenient handbook.

\* \* \*

**THE JOURNAL OF THE INSTITUTE OF METALS,** Vol. XIX. Edited by *G. Shaw Scott, M. Sc.* 316 pages. Price 21s. net. The Institute of Metals, 36 Victoria Street, London, S. W., England.

Among the various contributions published in this volume of the well known *Journal* may be mentioned "The Constitution of the Copper Rich Aluminum-Copper Alloys" by J. Neill Greenwood, and "An Investigation on Unsound Castings of Admiralty Bronze (88:10:2): Its Cause and the Remedy" by Prof. H. C. H. Carpenter and Miss C. F. Elam. An appreciation of the importance of the papers presented at the last meeting of the Institute may be gathered from the fact that the spoken and written discussion occupies much more space than the text of the contributions. Sixty pages of closely printed abstracts of the current literature on non-ferrous metallurgy close the volume, which, needless to remark, sustains the high tone of its predecessors.

## Personal

MR. H. K. BENSON has accepted a captain's commission in the Ordnance Department and has been assigned to the nitrate division for the investigation of the arc process in nitrogen fixation. Captain Benson was formerly professor of industrial chemistry and director of the Bureau of Industrial Research, University of Washington. During the past summer he made a field study of nitrogen products for the American Nitrogen Products Co., Seattle, Wash.

MR. F. W. BRUCKMILLER, formerly assistant professor of chemistry at the University of Kansas, is now chemist for Standard Oil Co. (Indiana) at Sugar Creek, Mo.

MESSRS. ALBERT BURCH and H. W. HARDINGE are in charge, respectively, of the Pacific Coast and Appalachian districts recently created by the U. S. Bureau of Mines for the purpose of making an inventory of manganese deposits and to assist in stimulating production. The country has been divided into four districts. In this same connection, G. H. CLEVINGER is stationed at Golden, Colorado, in charge of experiments in the metallurgy of manganese.

MR. LEONARD W. EGAN, formerly with the Wellman-Seaver-Morgan Co., has severed his connection with that concern and has become associated with the Electric Furnace Company as special engineer.

DR. HARRY S. FRY, formerly associate professor of chemistry, has been appointed professor and head of the department of chemistry at the University of Cincinnati. Other appointments in this department are as follows: DR. EARL F. FARNAU, associate professor of organic chemistry, formerly assistant professor of chemistry at New York University; DR. RALPH E. OESPER, associate professor of analytical chemistry, formerly assistant professor of chemistry at Smith College; DR. CLIFFORD J. ROLLE and DR. LEONORA NEUFFER, instructors in chemistry.

MR. S. GEJSBEEK of the Geijsbeek Engineering Company has been appointed district chief for Oregon, Washington and California for the Industrial Furnace Section, Bureau of Conservation, U. S. Fuel Administration.

MR. L. H. GOEBEL has resigned as superintendent of filtration and chief chemist of the Water Filtration Plant of the Union Stock Yard and Transit Company, Chicago, Ill., to become associated with the engineering staff of Wallace & Tiernan Company, manufacturers of chlorine control apparatus and sanitary engineering specialties.

MR. MAX K. GROSSHEIM has been put in charge of the engineering department of L. O. Koven & Brothers, Jersey City, N. J.

MR. ROBERT GEORGE HALL, formerly general manager of the River Smelting and Refining Co., St. Louis, Mo., has been appointed resident manager of the Burma Mines, Ltd., Nantau, Upper Shan States, Burma.

MR. VANCE McCARTY, for the past twelve years manager of the Pittsburgh branch of Edw. R. Ladew Company, Inc., has been appointed general sales manager of the company, with headquarters in the New York office, 54 Franklin Street.

MR. DWIGHT D. MILLER, formerly with the engineering department of the Society for Electrical Development, New York, is now with the Electric Furnace Co. of America, Alliance, Ohio, as manager of the New York office.

MR. JOHN D. RYAN, president of the Anaconda Copper Co., presented his resignation to the Board of Directors on Sept. 3. As Director of Aircraft Production, Mr. Ryan is now Assistant Secretary of War. Mr. C. F. Kelley will succeed Mr. Ryan as president.

MR. ERNEST B. TALKER is now connected with the Inland Steel Co., Indiana Harbor, Ind., as master mechanic of the furnace plant. He was formerly with the By-Product Coke Corp., South Chicago, Ill.



# Current Market Reports

## The Non-Ferrous Metal Market

**Monday, Sept. 9.**—The metal markets are very steady. The munition consumption gradually approaches the supply, but Government regulation prevents competitive buying by outsiders.

**Aluminium:**—The Government prices on ingots 98 to 99 per cent Al are \$660 a ton f.o.b. plant in 50-ton lots; \$662 down to 15-ton lots; and \$660 down to 1-ton lots, which prices will continue the remainder of the year. Prices per pound for small lots vary from 40 to 45c.; sheet aluminium, 18ga. and heavier, 42c.; powdered aluminium, 100 mesh, 70c.

**Antimony:**—The recent rise in antimony was but temporary, the price now being 14 to 14½c. for duty paid spot delivery.

**Chrome:**—Western production is now in slight excess of demand. The nominal quotation for 40 per cent ore is \$1.40 per unit, while 50 per cent ore is bringing \$1.70.

**Copper:**—The price of \$520 per ton for car load lots and 27.3c. per pound for small quantities is permanently fixed.

|                            |     |       |          |
|----------------------------|-----|-------|----------|
| Copper sheets, hot rolled  | lb. | \$ 36 | — \$ 37½ |
| Copper sheets, cold rolled | lb. | .37   | — .38½   |
| Copper bottoms             | lb. | .44   | — .45½   |
| Copper rods                | lb. | .36   | — .37    |
| Copper wire                | lb. | .29½  | — .30    |
| High brass wire            | lb. | .28½  | — .29½   |
| High brass sheets          | lb. | .28½  | — .29½   |
| High brass rods            | lb. | .26½  | — .28    |
| Low brass wire             | lb. | .32½  | — .34½   |
| Low brass sheets           | lb. | .32½  | — .34½   |
| Low brass rods             | lb. | .33½  | — .35½   |
| Brazed brass tubing        | lb. | .37   | — .39    |
| Brazed bronze tubing       | lb. | .42½  | — .44½   |
| Seamless copper tubing     | lb. | .41   | — .43    |
| Seamless bronze tubing     | lb. | .45   | — .46    |
| Seamless brass tubing      | lb. | .37½  | — .39½   |
| Bronze (gold) powder       | lb. | 1 00  | — 1 75   |

**Lead:**—The lead market is limited by selling restrictions. Producers must sell at a uniform and pre-arranged price. In car load lots at East St. Louis, the price is \$155 per unit. In New York, all speculative and traders' lead has disappeared. The Lead Committee apportions lead at 8.05c. to legitimate consumers.

**Manganese:**—The scale prices on page 629 of CHEMICAL & METALLURGICAL ENGINEERING, June 15, prevail; the highest price per unit being \$1.35.

**Zinc:**—Spelter continues to advance. East St. Louis is selling at \$183 to \$185 per ton in car lots; New York quotations are from 9.4 to 9.5c. per pound; sheet zinc 15c. and zinc dust (300 mesh) 16c. per pound in 1600-lb. casts.

**Tin:**—Outside tin prices are on the ebb, New York spot being at 80c. This seems to be due to a tendency of consumers to take the reins out of the market's hands and to proportion the available supplies; present prices being believed to be sufficient to maintain the maximum production physically possible. Babbitt metal varies between \$1.00 and 65c.; solder (50-50), 73c. per pound.

**Tungsten:**—The western producers of Scheelite are reluctant in offering at \$25.50 per unit. High grade Wolfgramite is bringing \$25. Off-grade ores vary from \$20, to \$24.

**Silver:**—The Government price of \$1.01½ is hoped to promote production.

### OTHER METALS

|           |        |        |           |
|-----------|--------|--------|-----------|
| Bismuth   | lb.    | \$ 35  | — \$ 65   |
| Cadmium   | lb.    | 1 50   | — 2 50    |
| Colalt    | lb.    | 2 50   | — 3 50    |
| Magnesium | lb.    | 1 75   | — 2 00    |
| Mercury   | 75 lb. | 125 00 | — . . . . |
| Mercury   | lb.    | 1 95   | — . . . . |
| Nickel    | lb.    | 40     | — . . . . |
| Iridium   | oz.    | 175 00 | — . . . . |
| Palladium | oz.    | 135 00 | — . . . . |
| Platinum  | oz.    | 105 00 | — . . . . |

## The Iron and Steel Market

With the total steel requirements for the half year, as estimated by the War Industries Board, increased to not less than 23,000,000 net tons, the supply will reach a shorter distance down the preference list than had been expected. As a matter of fact, in the majority of cases there will be no steel at all for purposes that are not distinguished

except by a place on the preference list. It may be well to explain that while shipments "on the preference list" follow shipments against priorities, the preference list itself is not confined to purposes for which priorities are not given. The preference list includes aircraft, munitions and in fact practically all the most important direct war requirements, for which priorities were for a long time granted individually by the War Industries Board, and for which "automatic priority" was provided in the regulations of last July. All priority business is represented on the preference list, but what are ordinarily classed as preference shipments are those made by virtue of the preference list and not by virtue of priorities.

Thus substantially all the steel shipped is shipped for purposes included in the preference list, but by far the major portion has the priority authority in addition. As to class D, or "permit" steel, which is steel that may be left after the preference list is taken care of, there is, practically speaking, no such thing. In every instance the steel would arise only by the making of off heats or of off material in rolling, and the percentage is very small. As a rule, apparently, mills are disposed to hold such steel on the chance of finding a priority or preference use for it, with its use as scrap as a last resort. Such use, indeed, seems to have been definitely recommended at a recent conference between the War Industries Board and representatives of the steel makers. Scrap being extremely scarce, there is an opportunity of increasing the supply of war steel by such use.

In the case of many producers it is impossible to provide any steel for plain preference purposes, the priority requirements being too extensive. There are many finishing departments that cannot go farther than to take care of all priorities of classes AA and A, with nothing left for the class B priorities, which run from 1 to 8. Steel for replacement of jobbers' stocks, as decreased by priority and preference shipments of jobbers, has B4 priority, and in the case of many mills the supply plays out in that class, the mill being able to ship some B4 steel but not all that has been scheduled. By about the end of August, practically all of the jobbers' August quotas had been scheduled by the mills, but some of the steel will not actually have been shipped by the end of this month.

### PRODUCTION

Production is increasing slightly over the July-August average, which was between 40,000,000 and 41,000,000 tons a year in pig iron and about 42,000,000 tons a year in steel ingots. While the weather was hot, particularly in the first 12 days of August, the curtailment in production on account of high temperatures was less than in any previous summer, the strenuous efforts of managers, foremen and many workmen serving to obviate very largely the relaxation that usually occurs.

In the case of pig iron production there seems to be three restrictive influences—coke, labor and manganese alloys. There has been continued complaint by some furnaces of poor quality coke and there has also been some actual shortage of coke. Both conditions have been taken strongly in hand by the Fuel Administration. For instance, at a meeting in Uniontown on September 4, Warren S. Blauvelt, director of the coke division of the Fuel Administration, met about 200 operators of the general Connellsville region and made a strong plea for the shipment of good, clean coke, urging that steel made now will save human lives by shortening the war. The Railroad Administration is cooperating by endeavoring to furnish absolutely full supplies of by-product coal to the by-product coke ovens, but there is not much to be gained in this respect, seeing that the Geological Survey reports have for months past shown very nearly full supplies, losses in by-product coke output through shortage of coal not having averaged more than perhaps 2 per cent. The efforts do not stop there, however, as there is a larger field for improvement in that as by-product ovens have been completed some beehive ovens have been closed in order to divert the coal to the by-product ovens. If coal from elsewhere can be provided, the closed beehive ovens can resume operations. The seriousness of this situation was brought out early in September, when



the weekly report of coke production, for the week ended August 24, was circulated. Comparing the four weeks ended May 18 and the four weeks ended August 24, there was a decrease in the weekly production of beehive coke of 95,000 tons and an increase in the production of by-product coke of 55,000 tons, showing a net loss of 55,000 tons, this representing, of course, an entirely unsatisfactory state of affairs.

As to labor restricting the production of pig iron, the cases are largely local, chiefly in Virginia, Alabama and Tennessee districts. With respect to the interference of manganese alloys, it is believed in many quarters in the trade that too many furnaces are operating on ferromanganese or spiegeleisen, there being about 20 altogether. It is quite clear that in the market pig iron is much scarcer than ferromanganese or spiegeleisen, and it may be that consumers have large stocks of the manganese alloys besides.

As to steel ingot production, the existing capacity under normal operating conditions could certainly be counted upon for at least 47,000,000 tons a year, whereas the highest rate of production attained has been the 43,500,000-ton rate of June, production in the past two months having been at a somewhat lower rate. On account of limited supplies of scrap and poor quality of what is available, rated outputs cannot be attained, but still it is probable that with an unlimited supply of pig iron more steel could be made.

#### DISTRIBUTION OF STEEL

The War Industries Board names railroad steel as the largest single item in the present requirements, shipbuilding coming second, Army needs, including those of our allies, third, and Navy needs fourth. This of course is not a normal sequence, the high place accorded railroad steel being due to the fact that taking care of the railroads was postponed in favor of more important needs, but cannot be postponed further on account of winter impending. The railroads have been functioning wonderfully well of late compared with their partial breakdown last winter, but cannot be expected to continue doing as well when inclement weather comes.

The combination of heavy rail demands for domestic roads and heavy demands for the A. E. F., an additional 200,000 tons having been ordered for the latter a few weeks ago, rail production is now at a heavy rate, and shell steel manufacture has been largely displaced at some rail mills. At the same time the shell steel requirements have greatly increased, by reason of Marshall Foch's great offensive, and the success the smaller guns have had. A large additional amount of shell steel will therefore have to be contributed by other lines. Two wire departments, Donora and Woodlawn, are being altered for the rolling of shell rounds instead of rod billets, as one contribution. Thus the production of wire will be curtailed and it is probable that production of merchant bars, of standard pipe and of sheets and tin plates will also be curtailed.

#### The Chemical Market

**COAL TAR PRODUCTS:**—The situation underwent but little change during the past two weeks, although of the important crudes benzol was in better demand and supplies are liberal. Chemical prices are inclined to a firmer tone than otherwise. The intermediates in general are in fair demand with prices having an upward tendency due to the restricted offerings.

**Benzol:**—A slight improvement is evident in the buying demand. Considerable interest has been shown in benzol for automobile propulsion which was created through the recent request of the Fuel Administration for the conservation of gasoline. The increase in demand however is not great enough to deplete the large quantities on the market and quotations are 23c. in spot in tank cars and 28c. spot, drums extra and returnable.

**Phenol:**—A quiet market prevails locally but it is said that some large exportations have been made to Japan where the material appears to be urgently needed. Supplies are plentiful and prices are 40c. export drums, but 43 to 44c. drums included are generally quoted.

**Diethylaniline:**—There are more offerings of this product, but buying interest is quiet, with spot material quoted at \$4 f.o.b. works.

**Paraphenylenediamine:**—Movement is running ordinarily; however, available material is limited and dealers offer no encouragement; prices range from \$4.00 to \$4.50 which appears to be about the firm level.

**Acetanilid:**—The demand is not heavy, although for a short period the item has had some activity. Offerings of the material are held at from 68 to 70c. for the U.S.P. and the technical is quoted at 65c.

**Para-amidophenol:**—Trading is seemingly steady and offerings are made by large dealers at from \$4.00 to \$4.50 for the base material.

**Dinitrophenol:**—Producers are concentrating their efforts for Government purposes and supplies are insufficient for immediate requirements. No spot is available and the nominal asking price is 52c.

**Aniline Oil:**—Limited stocks are reported and the demand is fair. Small scattered offerings tend to keep prices at firm levels of about 30c.

**Aniline Salts:**—The product is reported in only fair quantities and second hands are taking advantage of the situation, obtaining a range of prices by no means low for the small amount of material on hand.

**Beta Naphthol:**—Both sublimed and technical grades are in reasonable demand, but the production is not in proportion to requirements. Quotations remain at the firm level of from 80 to 90c. for the sublime and 60c. for the technical material.

**Benzidine Base:**—Offerings are liberal but the demand is only routine, with principal purchases being made for export purposes. Prices are quotable unchanged at \$1.75.

**HEAVY CHEMICALS:**—Trading generally has been fairly satisfactory, with the volume of business apparently on the increase. Prices have had an upward tendency with the exception of some items which are easier and not so firm in demand.

**Soda Ash:**—Consumption requirements are strong and offerings obtainable are being held at strong levels. Considerable speculation is rife and the price asked at New York is \$2.50. Double bags are quoted at works at about \$3.10 with barrels named at prices from \$2.80 to \$3.00. Dense ash from works is reported to be sold as high as \$4 double bags, with other quarters quoting \$3.70 double bags and barrels.

**Salt Cake:**—A lack of consuming interest has resulted with practically no change of position in this market. The general run of selling values is from \$22 to \$25 bulk Northern points.

**Caustic Soda:**—The market was more active during the past two weeks with recent sales at 4c. dock and warehouse. These prices, however, are not considered the market. The Government requirements are becoming more imperative and are now taking about one-quarter of the production. The Government has notified producers that, beginning November 1, their needs will be greater. Therefore, manufacturers have in turn notified firms holding contracts that in view of the priority of Government requirements, deliveries will be curtailed in proportion to the amount required by the Government.

**Yellow Prussiate of Soda:**—The market has not been marked with much change, but lack of demand is evident with regular traders quoting prices from 90c. to \$1.00.

**Bichromate of Soda:**—The situation has been somewhat easier with some business passing at 24c., but no interest is shown in the product at a higher figure.

**Potassium Permanganate of Soda:**—Despite the fact that potassium salt has declined in price to a marked extent, manufacturers of the soda solution continue to quote a price of \$3 per gallon.

**Copper Sulphate:**—Demand has been reasonably active of late with producers having the situation well in hand. Sales of spot have occurred at 9c.

**Sulphate of Alumina:**—A strong situation prevails in this market and consumers who find it necessary to cover are seemingly up against a rising market. Odd lots appear of the iron-free, having sold lately at from 1½ to 1¾c.

## General Chemicals

WHOLESALE PRICES IN NEW YORK MARKET, SEPT. 9, 1918

|                                                 |                    |               |        |
|-------------------------------------------------|--------------------|---------------|--------|
| Acetic anhydride                                | lb.                | 1.90          | 2.00   |
| Acetone                                         | lb.                | .25           | .25    |
| Acid, acetic, 28 per cent                       | cwt.               | 5.96          | 6.11   |
| Acetic, 50 per cent                             | cwt.               | 10.76         | 10.87  |
| Acetic, glacial, 99 1/2 per cent, carbonyl      | cwt.               | 19.50         | 19.70  |
| Aloric, crystals                                | lb.                | .13           | .15    |
| Citric, crystals                                | lb.                | .80           | .82    |
| Hydrochloric, C. P.                             | lb.                | Nominal       |        |
| Hydrofluoric, 30 per cent in barrels            | lb.                | .15           | .16    |
| Lactic, 44 per cent                             | lb.                | .06           | .07    |
| Lactic, 22 per cent                             | lb.                | 6.90          | 7.40   |
| Molybdic, C. P.                                 | lb.                | Nominal       |        |
| Nitric, 36 deg.                                 | lb.                | .08           | .10    |
| Nitric, 42 deg.                                 | lb.                | .42           | .44    |
| Oxalic, crystals                                | lb.                | .07           | .09    |
| Phosphoric, 47-50 per cent paste                | lb.                | .35           | .40    |
| Phosphoric, ref. 50 per cent                    | lb.                | Nominal       |        |
| Pyrogallol, resublimed                          | lb.                | 3.25          | 3.50   |
| Sulphuric, 60 deg.                              | ton                | 18.00         |        |
| Sulphuric, 66 deg.                              | ton                | 18.00         |        |
| Sulphuric, oleum (Fuming), tank cars            | ton                | 32.00         |        |
| Tannic, U. S. P., bulk                          | lb.                | 1.40          | 1.50   |
| Tartaric, crystals                              | lb.                | .82           | .83    |
| Tungstic, per lb. of W                          | lb.                | 1.70          | 1.75   |
| Alcohol, sugar cert., 188 proof                 | gal.               | 4.90          | 4.95   |
| Alcohol, wood, 95 per cent                      | gal.               | .91           | .92    |
| Alcohol, denatured, 180 proof                   | gal.               | .68           | .69    |
| Alum, ammonia lump                              | lb.                | .03           | .03    |
| Alum, chrome ammonium                           | lb.                | .18           | .19    |
| Alum, chrome potassium                          | lb.                | .20           | .21    |
| Alum, chrome sodium                             | lb.                | .12           | .13    |
| Alum, potash lump                               | lb.                | .12           | .13    |
| Aluminium sulphate, technical                   | lb.                | .02           | .02    |
| Aluminium sulphate, iron free                   | lb.                | .03           | .04    |
| Ammonia aqua, 26 deg., carbonyl                 | lb.                | .08           | .10    |
| Ammonia, anhydrous                              | lb.                | Nominal       |        |
| Ammonium carbonate                              | lb.                | .13           | .14    |
| Ammonium nitrate                                | lb.                | (Fixed Price) |        |
| Ammonium sulphate domestic                      | lb.                | .07           | .08    |
| Amyl acetate                                    | gal.               | 5.30          | 5.35   |
| Arsenic, white                                  | lb.                | .09           | .10    |
| Arsenic, red                                    | lb.                | .65           | .72    |
| Barium carbonate, 99 per cent                   | ton                | 85.00         | 90.00  |
| Barium carbonate, 97-98 per cent                | ton                | 60.00         | 67.00  |
| Barium chloride, 99 per cent                    | ton                | 65.00         | 70.00  |
| Barium sulphate (Blanc Fixe, Dry)               | lb.                | .02           | .06    |
| Barium nitrate                                  | lb.                | .14           | .15    |
| Barium peroxide, basis 70 per cent              | lb.                | .30           | .32    |
| Calcining powder, 35 per cent chlorine          | lb.                | .03           | .04    |
| Borax, crystals, acids                          | lb.                | .07           | .10    |
| Bromine, crude                                  | ton                | Nominal       |        |
| Bromine, technical                              | lb.                | .75           | .84    |
| Calcium acetate, crude                          | lb.                | .04           | .05    |
| Calcium, carbide                                | lb.                | .19           | .20    |
| Calcium chloride, 70-75 per cent, fused, lump   | ton                | 22.00         | 24.00  |
| Calcium peroxide                                | lb.                | 1.50          | 1.70   |
| Calcium phosphate                               | lb.                | .22           | .23    |
| Calcium sulphate 98-99 per cent                 | lb.                | .09           | .09    |
| Carbon bisulphide                               | lb.                | .08           | .09    |
| Carbon tetrachloride, drums                     | lb.                | Nominal       |        |
| Carbonyl chloride (phosgene)                    | lb.                | 1.10          | 1.50   |
| Cause potash, 85-92 per cent                    | lb.                | .60           | .75    |
| Cautic soda, 76 per cent                        | 100 lb.            | 4.15          | 4.50   |
| Chlorine, liquid (Government Purchase)          | lb.                | (Fixed Price) |        |
| Lead oxide                                      | lb.                | 1.65          | .07    |
| Copper                                          | lb.                | .02           | .02    |
| Copper carbonate                                | lb.                | .30           | .31    |
| Copper cyanide                                  | lb.                | .75           | .78    |
| Copper sulphate, 99 per cent, large crystals    | lb.                | .75           | .78    |
| Crown of tartar, crystals                       | lb.                | .94           | .99    |
| Epsom salt, bags, U. S. P.                      | 100 lb.            | 3.62          | 3.90   |
| Formaldehyde, 40 per cent                       | lb.                | .16           | .17    |
| Glauber's salt                                  | lb.                | .63           | .63    |
| Glycerine, bulk, C. P.                          | lb.                | .02           | .03    |
| Iodine, resublimed                              | lb.                | 4.25          | 4.30   |
| Iron oxide                                      | lb.                | .13           | .15    |
| Lead acetate, white crystals                    | lb.                | .17           | .17    |
| Lead arsenite (Paste)                           | lb.                | .15           | .18    |
| Lead nitrate                                    | lb.                | Nominal       |        |
| Litharge, American                              | lb.                | .12           | .14    |
| Lithium carbonate                               | lb.                | 1.50          | 2.00   |
| Magnesium carbonate, technical                  | lb.                | .16           | .17    |
| Nickel salt, single                             | lb.                | .14           | .15    |
| Nickel salt, double                             | lb.                | .12           | .13    |
| Phosgene, (see Carbonyl chloride)               | lb.                | 1.10          | 1.50   |
| Phosphorus, red                                 | lb.                | 1.00          | 1.15   |
| Phosphorus, yellow                              | lb.                | 1.08          | 1.15   |
| Potassium bichromate                            | lb.                | .45           | .46    |
| Potassium bromide granular                      | lb.                | 1.25          | 1.26   |
| Potassium carbonate calcined, 85-90 per cent    | lb.                | .38           | .40    |
| Potassium chlorate, crystals                    | lb.                | .40           | .41    |
| Potassium cyanide, 98-99 per cent               | lb.                | .60           | .60    |
| Potassium iodide                                | lb.                | 3.75          | 3.80   |
| Potassium muriate 80-85 p. c. basis of 80 p. c. | ton                | 300.00        | 350.00 |
| Potassium nitrate                               | lb.                | .27           | .31    |
| Potassium permanganate U. S. P.                 | lb.                | 1.30          | 1.75   |
| Potassium persulfate, red                       | lb.                | 2.30          | 2.50   |
| Potassium persulfate, yellow                    | lb.                | 1.00          | 1.10   |
| Potassium sulphate, 90-95 p. c. basis 90 p. c.  | ton                | Nominal       |        |
| Rochelle salt                                   | lb.                | .47           | .48    |
| Salammoniac, gray gran                          | lb.                | Nominal       |        |
| Salammoniac, white gran                         | lb.                | .19           | .20    |
| Salt soda                                       | 100 lb.            | 1.40          | 1.65   |
| Salt cake                                       | ton                | 22.50         | 25.00  |
| Silver cyanide, based on market price of silver | oz.                | .63           | .64    |
| Silver nitrate                                  | lb.                | .63           | .64    |
| Soda ash, 58 per cent, light, flat (bags)       | 100 lb.            | 2.45          | 2.50   |
| Soda ash, 58 per cent, dense, flat              | 100 lb.            | 3.75          | 3.80   |
| Sodium acetate                                  | lb.                | Nominal       |        |
| Sodium bicarbonate, domestic                    | lb.                | 2.75          | 3.00   |
| Sodium bicarbonate, English                     | lb.                |               |        |
| Sodium bichromate                               | lb.                | .23           | .26    |
| Sodium bisulphite, powd.                        | lb.                | .14           | .12    |
| Sodium chlorate                                 | lb.                | 2.25          | 2.5    |
| Sodium cyanide                                  | lb.                | .40           | .42    |
| Sodium fluoride, commercial                     | lb.                | .17           | .18    |
| Sodium hyposulphite                             | lb.                |               |        |
| Sodium molybdate, per lb. of Mo                 | lb.                |               |        |
| Sodium nitrate, 95 per cent                     | 100 lb.            | 2.50          | 5.00   |
| Sodium nitrite                                  | lb.                | .27           | .30    |
| Sodium peroxide                                 | lb.                | .35           | .45    |
| Sodium phosphate                                | lb.                | .04           | .05    |
| Sodium pyrosulphate, yellow                     | lb.                | .35           | .45    |
| Sodium silicate, liquid (60 deg.)               | lb.                | .02           | .03    |
| Sodium sulphide, 30 per cent, crystals          | lb.                | .06           | .07    |
| Sodium sulphide, 60 per cent, fused             | 100 lb.            | 9.60          | 10.00  |
| Sodium sulphate                                 | lb.                | .25           | .30    |
| Strontium citrate                               | lb.                | .25           | .30    |
| Sulphur chloride, drums                         | lb.                | .07           | .09    |
| Sulphur dioxide, liquid, in cylinders           | lb.                | .15           | .40    |
| Sulphur, flowers, sublimed                      | 100 lb.            | .41           | .45    |
| Sulphur, roll                                   | 100 lb.            | 3.70          | 3.85   |
| Sulphur, crude                                  | ton                | 65.00         | 70.00  |
| Tin bichloride, 50 deg.                         | lb.                | .28           | .20    |
| Tin oxide                                       | lb.                | Nominal       |        |
| Zinc carbonate                                  | lb.                | .18           | .24    |
| Zinc chloride                                   | lb.                | .15           | .15    |
| Zinc cyanide                                    | lb.                | Nominal       |        |
| Zinc dust, 350 mesh                             | lb.                | .15           | .15    |
| Zinc oxide, American process                    | lb.                | .12           | .14    |
| Zinc sulphate                                   | lb.                | .04           | .06    |
| Benzol, pure, water white                       | gal.               | .23           | .28    |
| Benzol, 90 per cent                             | gal.               | .25           |        |
| Toluol, in tank cars                            | gal. (Fixed Price) | 1.50          |        |
| Toluol, for non-military use, in drums          | gal. (Fixed Price) | 1.55          |        |
| Xylol, pure, water white                        | gal.               | .45           | .55    |
| Solvent naphtha, water white                    | gal.               | .18           | .25    |
| Solvent naphtha, crude, heavy                   | gal.               | .12           | .15    |
| Cresote oil, 25 per cent                        | gal.               | .45           | .55    |
| Dip oil, 20 per cent                            | ton                | 8.00          | 10.00  |
| Pitch, various grades                           | ton                | 19.00         | 20.00  |
| Carbolic acid, crude, 95-97 per cent            | lb.                | 1.05          | 1.10   |
| Carbolic acid, crude, 50 per cent               | lb.                | .60           | .65    |
| Carbolic acid, crude, 25 per cent               | lb.                | .35           | .38    |
| Cresol, U. S. P.                                | lb.                | .19           | .20    |
| Alpha naphthol, crude                           | lb.                | 1.00          | 1.10   |
| Alpha naphthol, refined                         | lb.                | 1.50          | 1.60   |
| Alpha naphthylamine                             | lb.                | .60           | .60    |
| Aniline oil, drums extra                        | lb.                | .28           | .30    |
| Aniline salts                                   | lb.                | .44           | .45    |
| Anthraccene, 80 per cent                        | lb.                | Nominal       |        |
| Benzaldehyde (f.f.c.)                           | lb.                | 3.60          | 4.00   |
| Benzidine, base                                 | lb.                | 1.15          | 1.85   |
| Benzidine, sulphate                             | lb.                | 1.40          | 1.45   |
| Benzic acid U. S. P.                            | lb.                | 2.65          | 2.85   |
| Benzoate of Soda, U. S. P.                      | lb.                | 2.65          | 2.85   |
| Benzyl chloride                                 | lb.                | 1.50          | 1.60   |
| Beta naphthol benzoate                          | lb.                | 10.00         | 12.00  |
| Beta naphthol, sublimed                         | lb.                | .85           | .90    |
| Beta naphthylamine, sublimed                    | lb.                | 2.65          | 2.75   |
| Dichlor benzol                                  | lb.                | 1.15          | 1.20   |
| Diethylaniline                                  | lb.                | 4.00          | 4.50   |
| Dinitro benzol                                  | lb.                | .36           | .38    |
| Dinitrochlorobenzol                             | lb.                | .40           | .45    |
| Dinitrophenylamine                              | lb.                | .55           | .60    |
| Dinitrotoluol                                   | lb.                | .65           | .75    |
| Dinitrophenol                                   | lb.                | .55           | .60    |
| Dimethylamine                                   | lb.                | .74           | .76    |
| Diphenylamine                                   | lb.                | 1.75          | 1.85   |
| H-acid                                          | lb.                | 3.00          | 3.40   |
| Metaphenylenediamine                            | lb.                | 1.85          | 2.05   |
| Monochlorobenzol                                | lb.                | .17           | .20    |
| Naphthalene, flakes                             | lb.                | .09           | .09    |
| Naphthalene, balls                              | lb.                | .11           | .12    |
| Naphthionic acid, crude                         | lb.                | 1.20          | 1.30   |
| Naphthylamine-di sulphonic acid                 | lb.                | 1.00          | 1.10   |
| Nitro naphthaline                               | lb.                | .55           | .60    |
| Nitro toluol                                    | lb.                | .55           | .60    |
| Ortho-amidophenol                               | lb.                |               | .20    |
| Ortho-dichlor-benzol                            | lb.                | .15           | .20    |
| Ortho-toluidine                                 | lb.                | .95           | 1.10   |
| Ortho-nitro-toluol                              | lb.                | .75           | .85    |
| Para-amidophenol, base                          | lb.                | 4.00          | 4.50   |
| Para-amido-phenol, H. Ch.                       | lb.                | 4.25          | 5.00   |
| Para-dichlor-benzol                             | lb.                | .15           | .20    |
| Paranitraniline                                 | lb.                | 1.80          | 2.00   |
| Para-nitro-toluol                               | lb.                | 1.50          | 1.60   |
| Paraphenylenediamine                            | lb.                | 3.75          | 4.00   |
| Para toluidine                                  | lb.                | 4.00          | 4.25   |
| Phthalic acid anhydride                         | lb.                | 4.00          | 4.50   |
| Phenol, U. S. P.                                | lb.                | .40           | .45    |
| Resorcin, technical                             | lb.                | 9.00          | 7.00   |
| Resorcin, pure                                  | lb.                | 8.00          | 9.00   |
| S-leylic acid                                   | lb.                | .85           | .95    |
| Solol                                           | lb.                | 1.50          | 2.00   |
| Sulphanilic acid, crude                         | lb.                | .32           | .34    |
| Tolidin                                         | lb.                | 2.50          | 3.00   |
| Toluidine-mixture                               | lb.                | .85           | .90    |
| Pennsylvania                                    | bbl.               | 4.00          |        |
| Corning, Ohio                                   | bbl.               | 2.60          |        |
| Somerset, Ky.                                   | bbl.               | 2.60          |        |
| Wester, Ohio                                    | bbl.               | 2.68          |        |
| Indiana                                         | bbl.               | 2.28          |        |
| Illinois                                        | bbl.               | 2.28          |        |
| Oklahoma and Kansas                             | bbl.               | 2.25          |        |
| Caddo, La., light                               | bbl.               | 2.25          |        |
| Corianna, Tex., light                           | bbl.               | 2.25          |        |
| California                                      | bbl.               | 1.15          | 1.57   |
| Gulf Coast                                      | bbl.               | 1.35          |        |
| Mexican                                         | bbl.               | 1.90          |        |
| New York                                        | gal.               | .15           |        |
| Philadelphia                                    | gal.               | .101          | 151c   |
| Baltimore                                       | gal.               | .078          |        |
| Pittsburgh                                      | gal.               | .071          | .10    |
| Texas                                           | bbl.               | 1.85          | 2.35   |
| Los Angeles                                     | bbl.               | 1.65          |        |

Petroleum Oils  
Crude (at the Wells)

## Fuel Oil

## Gasoline (Wholesale)

|                    |      |    |    |
|--------------------|------|----|----|
| New York.....      | gal. | 24 | —  |
| Gas machine.....   | gal. | 41 | —  |
| 72-76 degrees..... | gal. | 33 | 39 |
| 70-72 degrees..... | gal. | 37 | —  |
| 67-70 degrees..... | gal. | 30 | 36 |
| Pittsburgh.....    | gal. | 25 | —  |
| Chicago.....       | gal. | 27 | 23 |
| Oklahoma.....      | gal. | 21 | —  |
| San Francisco..... | gal. | 20 | —  |

## Paraffine Waxes

|                              |     |    |    |
|------------------------------|-----|----|----|
| Crude, 103 to 105 deg. m.pt. | lb. | 08 | 09 |
| Crude, 118 to 120 deg. m.pt. | lb. | 09 | 10 |
| Crude, 126 to 128 deg. m.pt. | lb. | 10 | —  |
| Refined, 120 deg. m.pt.      | lb. | 13 | —  |
| Refined, 128 deg. m.pt.      | lb. | 14 | —  |
| Refined, 135 deg. m.pt.      | lb. | 16 | 16 |
| Osokerite, brown.....        | lb. | 25 | —  |
| Osokerite, green.....        | lb. | 85 | —  |

## Lubricants

|                                                  |      |    |    |
|--------------------------------------------------|------|----|----|
| Black, reduced, 29 gravity, 25-30 cold test..... | gal. | 24 | 25 |
| Cylinder, light.....                             | gal. | 45 | 50 |
| Cylinder, dark.....                              | gal. | 39 | 41 |
| Paraffine, high viscosity.....                   | gal. | 40 | 41 |
| Paraffine, 903 sp. gr.....                       | gal. | 36 | 38 |
| Paraffine, 885 sp. gr.....                       | gal. | 26 | 28 |

## Flotation Oils

(Prices at New York unless otherwise stated)

|                                                                        |      |    |    |
|------------------------------------------------------------------------|------|----|----|
| Pine oil, crude, f. o. b. Florida.....                                 | gal. | 44 | —  |
| Pine oil, steam-distilled, sp. gr. 0.925-0.940.....                    | gal. | 58 | 60 |
| Pine oil, destructively distilled.....                                 | gal. | 58 | 60 |
| Pine-tar oil, sp. gr. 1.02-1.035.....                                  | gal. | 35 | —  |
| Pine-tar oil, double refined, sp. gr. 0.965-0.990.....                 | gal. | 42 | —  |
| Pine-tar oil, ref., light, sp. gr. 0.950, tank cars, f.o.b. works..... | gal. | 37 | —  |
| Pine-tar oil, ref., heavy, sp. gr. 1.025, tank cars, f.o.b. works..... | gal. | 28 | —  |
| Pine-tar oil, ref., thin, sp. gr. 1.060-1.080.....                     | gal. | 32 | —  |
| Turpentine, crude, sp. gr. 0.870-0.900.....                            | gal. | 45 | —  |
| Hardwood oil, f. o. b. Michigan, sp. gr. 0.960-0.990.....              | gal. | 23 | —  |
| Hardwood oil, f. o. b. Michigan, sp. gr. 1.06-1.08.....                | gal. | 23 | —  |
| Wood creosote, ref. f. o. b. Florida.....                              | gal. | 31 | —  |

## Naval Stores

|                                               |               |       |       |
|-----------------------------------------------|---------------|-------|-------|
| Rosin A-E barrel.....                         | 280 lb.       | 13 25 | 13 50 |
| Rosin F-I.....                                | 280 lb.       | 13 60 | 14 00 |
| Rosin K-N.....                                | 280 lb.       | 15 00 | 15 40 |
| Rosin W-G.....                                | 280 lb.       | 15 50 | 15 75 |
| Spirits of turpentine.....                    | gal.          | 66    | 67    |
| Wood turpentine, steam distilled.....         | gal.          | 63    | —     |
| Wood turpentine, destructively distilled..... | gal.          | 58    | —     |
| Pitch.....                                    | bbbl. 200 lb. | 7 50  | —     |
| Tar, kiln dried.....                          | 280 lb.       | 12 50 | —     |
| Retort tar.....                               | 280 lb.       | 13 50 | —     |
| Rosin nil, first run.....                     | gal.          | 69    | —     |
| Second run.....                               | gal.          | 72    | —     |
| Third run.....                                | gal.          | 75    | —     |
| Fourth run.....                               | gal.          | 85    | —     |
| Castor oil.....                               | lb.           | 28    | 30    |
| China wood oil.....                           | lb.           | 29    | 29    |
| Cocoon oil.....                               | lb.           | 17    | 21    |
| Corn oil.....                                 | lb.           | 18    | —     |
| Cottonseed oil, crude.....                    | lb.           | 20    | 22    |
| Linseed oil, raw, cars.....                   | gal.          | 1 88  | 1 90  |
| Olive oil.....                                | gal.          | 4 25  | 4 50  |
| Peanut oil, crude.....                        | lb.           | 18    | 22    |
| Soya bean oil, Manchuria.....                 | lb.           | 16    | 18    |

## Glues

|                                 |      |      |      |
|---------------------------------|------|------|------|
| Extra white.....                | lb.  | 36   | 45   |
| Cabinet.....                    | lb.  | 31   | 40   |
| Brown foot stock.....           | lb.  | 18   | 22   |
| Fish glue, 50-gal. barrels..... | gal. | 1 00 | 1 80 |

## Miscellaneous Materials

|                                          |         |       |       |
|------------------------------------------|---------|-------|-------|
| Barytes, floated, white, foreign.....    | ton     | 38 00 | 42 00 |
| Barytes, floated, white, domestic.....   | ton     | 25 00 | 36 00 |
| Bauxite, white, pure.....                | lb.     | 38    | 43    |
| Bauxite, unbleached.....                 | lb.     | 43    | 46    |
| Blaine flux.....                         | lb.     | 05    | —     |
| Casolin.....                             | lb.     | 17    | 28    |
| Ceylon graphite.....                     | lb.     | 23    | 25    |
| Chalk, light, precipitated, English..... | ton     | 04    | —     |
| China clay, imported, lump.....          | ton     | 20 00 | 40 00 |
| China clay, domestic, lump.....          | ton     | 15 00 | 22 50 |
| Flint spar.....                          | ton     | 8 00  | 12 00 |
| Fluor spar, gravel, f. o. b. mine.....   | ton     | 60 00 | —     |
| Fluor spar, washed, powdered.....        | ton     | 90 00 | —     |
| Fuller's earth, powdered.....            | 100 lb. | 1 50  | 2 00  |
| Iron wash.....                           | ton     | 18    | 25    |
| Mexican graphite.....                    | ton     | 75 00 | —     |
| Madagascar graphite.....                 | lb.     | 10    | 13    |
| Orange shellac.....                      | lb.     | 75    | 80    |
| Pyrites stone.....                       | ton     | 8 00  | 08    |
| Red lead, dry, carloads.....             | 100 lb. | 11 84 | —     |
| Soapstone.....                           | ton     | 15 00 | 25 00 |
| Sulphuric acid, 120 deg. m. p.t.....     | lb.     | 13    | —     |
| Sulphuric acid, 140 deg. m. p.t.....     | lb.     | 19    | —     |
| Talc, American, white.....               | ton     | 20 00 | 40 00 |
| White lead, dry.....                     | lb.     | 09    | 10    |

## Refractories, Etc.

(F. O. B. Works)

|                                       |                |        |        |
|---------------------------------------|----------------|--------|--------|
| Chrome brick.....                     | net ton        | 175 00 | —      |
| Chrome cement.....                    | net ton        | 75 00  | —      |
| Clay brick, 1st quality fireclay..... | per 1000 50    | 53 00  | —      |
| Clay brick, second quality.....       | per 1000 35 00 | 40 00  | —      |
| Magnesite, raw.....                   | ton            | 30 00  | 35 00  |
| Magnesite, calcined, powdered.....    | ton            | 50 00  | 65 00  |
| Magnesite, dead burned.....           | net ton        | 50 00  | 60 00  |
| Magnesia brick, 9x4x2 1/2.....        | net ton        | 110 00 | 125 00 |
| Silica brick.....                     | per 1000 50 00 | 60 00  | —      |

## Ferroalloys

|                                                                          |     |        |        |
|--------------------------------------------------------------------------|-----|--------|--------|
| Ferrocobalt, 15-18 per cent, carloads, f. o. b. Niagara Falls, N. Y..... | ton | 200 00 | 250 00 |
| Ferrocobalt.....                                                         | lb. | 15 00  | 30 00  |
| Ferrocobalt, per lb. of Cr.....                                          | lb. | 30     | 40     |
| Ferromanganese, domestic, 70 per cent basis.....                         | ton | 250 00 | —      |
| Ferromanganese, English.....                                             | ton | 325 00 | —      |
| Spiegeleisen (16-18%).....                                               | ton | 75 00  | —      |
| Ferromolybdenum, per lb. of Mo.....                                      | lb. | 4 00   | 4 50   |
| Ferrosilicon, 75 per cent, f. o. b. N. Y.....                            | ton | 160 00 | 170 00 |
| Ferrosilicon, 50 per cent, carloads, del., Pittsburgh.....               | ton | 180 00 | 190 00 |
| Ferrosilicon, 50 per cent, contract.....                                 | ton | 160 00 | 170 00 |
| Ferrotungsten, 75-85 per cent, f. o. b. Pittsburgh.....                  | lb. | 2 35   | 2 40   |
| Ferrosilicium, f. o. b. works, per lb. of U.....                         | lb. | 7 50   | —      |
| Ferrovandium, f. o. b. works.....                                        | lb. | —      | —      |

## Ores and Semi-finished Products

|                                                                 |      |       |         |
|-----------------------------------------------------------------|------|-------|---------|
| Antimony ore, per unit.....                                     | ton  | 1 50  | Nominal |
| Chromite ore, 45 per cent minimum, f. o. b. Cal., per unit..... | ton  | 1 40  | 1 55    |
| Chromite ore, 43 per cent and over, New York, per unit.....     | ton  | 1 20  | —       |
| Manganese ore, 48 per cent and over, per unit.....              | ton  | 80 00 | 100 00  |
| Manganese ore, chemical.....                                    | ton  | 75    | —       |
| Molybdenite, per lb. of MoS.....                                | lb.  | 10 50 | —       |
| Tungsten, Scheelite, per unit of WO.....                        | ton  | 25 50 | —       |
| Tungsten, Wolframite, per unit of WO.....                       | ton  | 24 00 | —       |
| Uranium oxide, 96%.....                                         | lb.  | 3 25  | 3 60    |
| Vanadium pentoxide, 99%.....                                    | lb.  | 10 50 | —       |
| Pyrites, foreign.....                                           | unit | 17    | —       |
| Pyrites, domestic.....                                          | unit | 28    | 30      |

## Plant Supplies

## BUILDING MATERIALS

|                                              |         |        |        |
|----------------------------------------------|---------|--------|--------|
| Common clay bricks.....                      | M       | 13 00  | 14 00  |
| Hollow tile, 4 x 12 x 12.....                | M       | 60 00  | —      |
| Hollow tile, 12 x 12 x 12.....               | M       | 170 00 | —      |
| Lime.....                                    | ton     | 16 50  | —      |
| Portland cement.....                         | bbbl.   | 2 59   | —      |
| Single glass (82-lb.), 10 x 26-16 x 24.....  | ton     | 21 00  | 27 00  |
| Double glass (164 lb.), 10 x 26-16 x 29..... | ton     | 31 00  | 39 00  |
| Yellow pine lumber.....                      | M       | 39 00  | 45 00  |
| Fir lumber.....                              | M       | 38 00  | 53 00  |
| Hemlock.....                                 | M       | 24 50  | 40 00  |
| Tarred felt (14-lb. sq.).....                | ton     | 64 00  | —      |
| Roofing pitch.....                           | ton     | 14 00  | —      |
| Asphalt coated roofing (35-55-lb. sq.).....  | sq      | 1 30   | 2 50   |
| State surfaced asphalt shingles.....         | sq      | 5 25   | 5 50   |
| Corrugated galvanized iron.....              | ton     | 109 00 | 127 00 |
| Putty.....                                   | 100 lb. | 6 75   | —      |
| Red oxide (Ppte. Coppera).....               | ton     | 15 00  | 20 00  |
| Native red oxide.....                        | 100 lb. | 3 25   | 8 00   |
| Red metallic paint.....                      | 100 lb. | 1 70   | —      |
| White lead in oil.....                       | 100 lb. | 13 50  | 11 42  |
| Red lead in oil.....                         | 100 lb. | 14 00  | 11 84  |
| Zinc oxide (dry).....                        | 100 lb. | 13 00  | 14 50  |
| Zinc oxide—leaded.....                       | 100 lb. | 9 00   | 10 00  |
| Yellow ochre.....                            | 100 lb. | 1 50   | 10 00  |
| Ultra marine blue.....                       | 100 lb. | 14 00  | 50 00  |
| Prussian blue.....                           | 100 lb. | 135 00 | 150 00 |
| Chrome green.....                            | 100 lb. | 40 00  | —      |
| Paris green.....                             | 100 lb. | 43 00  | 49 00  |
| Mineral black.....                           | 100 lb. | 1 75   | 2 25   |
| Powdered bone black.....                     | 100 lb. | 5 50   | 12 00  |
| Lampblack.....                               | 100 lb. | 15 00  | 45 00  |
| Gas carbon.....                              | 100 lb. | 16 00  | 25 00  |
| Mexican petroleum pitch.....                 | 100 lb. | 1 00   | 2 00   |
| Gilemite.....                                | 100 lb. | 2 00   | 2 50   |
| Coal tar pitch.....                          | 100 lb. | 40     | —      |

## STRUCTURAL IRON

|                                        |     |        |        |
|----------------------------------------|-----|--------|--------|
| Blue annealed sheet iron.....          | ton | 84 00  | 89 00  |
| Black sheet iron.....                  | ton | 96 00  | 104 00 |
| Galvanized iron.....                   | ton | 105 00 | 170 00 |
| Tern plate, 8-lb. coating.....         | ton | 150 00 | —      |
| Tern plate, 15-lb. coating.....        | ton | 177 50 | —      |
| Tern plate, 25-lb. coating.....        | ton | 200 00 | —      |
| Tern plate, 40-lb. coating.....        | ton | 240 00 | —      |
| Tin plate, prime.....                  | ton | 155 00 | —      |
| Tank plates.....                       | ton | 65 00  | 70 00  |
| Beams, channels, angles, T's, Z's..... | ton | 60 00  | 65 00  |
| Rivets.....                            | ton | 88 00  | 92 00  |
| Steel plate, 1/2 to 3-inch.....        | ton | 51 00  | —      |
| Bar iron and steel.....                | ton | 60 00  | 70 00  |
| Chain (1 inch proof coil).....         | ton | 150 00 | —      |
| Nails, bolts, nuts, washers.....       | ton | 70 00  | 80 00  |
| Tool steels, special alloys.....       | ton | 300 00 | 500 00 |
| Bessemer pig iron.....                 | ton | 25 25  | —      |
| Bessemer steel.....                    | ton | 47 50  | —      |
| No. 2 foundry.....                     | ton | 33 50  | —      |
| Steel billets (4 x 4).....             | ton | 47 50  | —      |

## POWER HOUSE SUPPLIES

|                                   |     |      |      |
|-----------------------------------|-----|------|------|
| Steam packing, rubber duck.....   | lb. | 99   | 1 10 |
| Asbestos, high pressure.....      | lb. | 1 76 | —    |
| Asbestos, medium pressure.....    | lb. | 1 50 | —    |
| Asbestos, graphited braid.....    | lb. | 1 21 | —    |
| Asbestos, wick.....               | lb. | 75   | —    |
| Rubber, sheet.....                | lb. | 66   | —    |
| Cup grease.....                   | lb. | 07   | —    |
| Transmission grease.....          | lb. | 07   | —    |
| Axle grease.....                  | lb. | 04   | —    |
| Gear grease.....                  | lb. | 08   | —    |
| Cotton waste.....                 | lb. | 08   | 13   |
| Hose, underwriters, 2 1/2 in..... | ft. | 75   | —    |
| Hose, air, 1 in.....              | ft. | 30   | 60   |



# INDUSTRIAL NEWS

## Plant Construction—Catalogs—New Publications

### Construction and Operation

#### Alabama

**BIRMINGHAM**—The Magic City Cotton Co., 10th St. and 12th Ave., North, will rebuild its plant recently destroyed by fire entailing a loss of \$100,000.

**SELMA**—A. G. Kahn Brick Co., will rebuild its plant recently destroyed by fire entailing a loss of \$15,000.

**SHEFFIELD**—The North Alabama Rolling Mill Co., will expend \$300,000 to remodel and enlarge its plant. The company manufactures steel from waste or scrap. This project will be financed by the War Industries Board.

#### Arkansas

**ANDERSON**—Glenn L. Brunner, will build a 40-ton log washer plant for concentration of manganese ore at his mine here, and is in the market for steam shovel, engine, boilers, belts, lumber, roofing, concrete, conveyors, scales, ore cars, wagons for hard ore, jig, pumps, piping and mill hardware. Estimated cost, \$25,000. E. Berry, superintendent.

**BATESVILLE**—The Poke Southern Arkansas Mining Co. will build a 50-ton log washer plant and is in the market for log washer, mill belts, roofing, engine, pump, piping, mill hardware and concrete. Estimated cost, \$25,000.

#### California

**KINGSBURG**—The city has awarded the contract for the construction of a sewage disposal system, including Imhoff tank, to Frederickson & Sharmon, 2323 Washington St., Fresno. Estimated cost, \$27,102.

**LOS ANGELES**—The Thos. H. Ince Moving Picture Co., Hollywood, has awarded the contract for the construction of a reinforced concrete and steel motion picture studio, to include a laboratory, on Washington Boulevard and Sherman Way, to the Milwaukee Building Co., 1006 Pabst Building, Milwaukee, Wisconsin. Estimated cost, \$150,000.

**PASADENA**—The city commissioners of Pasadena, South Pasadena and Alhambra, have awarded the contract for the construction of an experimental sewage disposal plant using the Trent process to L. C. Trent Co., Pasadena. Estimated cost, \$7000.

#### Connecticut

**STAMFORD**—Baer Brothers, 700 Canal St., will build two factories, one on Canal St. and one on Fairfield Ave. for the manufacture of bronze powder. Estimated cost, \$375,000. A. Freeman, 29 West 34th St., New York City, architect.

**WATERBURY**—The Chase Metal Co., Waterville St., will build a 1-story, 40 x 32 ft., brass mill on Thomaston Ave. Estimated cost, \$40,000.

#### Florida

**FORT MYERS**—The Ocean Leather Co., 82 Beaver St., New York City, will build a plant for the manufacture of fertilizer and smoke and cure fish. Estimated cost, \$30,000.

**PENSACOLA**—The Bureau of Yards and Docks, Navy Department, Wash., D. C., will build a photo-laboratory, and oil reclaiming building. Estimated cost, \$620,000.

#### Georgia

**ATTAPELUS**—The Lester Clay Co. will rebuild its fuller's earth plant recently destroyed by fire, entailing a loss of \$100,000.

#### Illinois

**CHICAGO**—The Amalgamated Machine Corp., Racine and 37th St., will build a 1-story, concrete and steel plant for the manufacture of large gun boring machines. Estimated cost, \$500,000.

**GREAT LAKES**—The Bureau of Yards and Docks, Navy Department, Wash., D. C., received low bid for addition to disposal plant from the Embankment Co., Joliet, Ill. Estimated cost, \$31,420.

**MADISON**—The Barker Asphalt Co. has awarded the contract for the construction of a 1-story, 100 x 160 ft. concrete, brick and steel factory, the Austin Co., 1611 Euclid Ave., Cleveland. Estimated cost, \$50,000.

#### Iowa

**MARSHALLTOWN**—The Prier Brass Manufacturing Co., c/o W. H. Prier, will build a 1-story, 60 x 160 ft., brick foundry.

#### Kansas

**BAXTER SPRINGS**—The Buck Shot Mining Co., Miami, Okla., will remove its 250-ton concentration plant from Joplin, Mo., and remodel same. It is in the market for sludge and slime tables, belts, mill hardware, roofing, conveyors, etc. Estimated cost, \$35,000.

**BAXTER SPRINGS**—The Lucky Girl Mining Co., Carthage, Mo., will build a 200-ton concentration plant and is in the market for sludge and slime tables, ore bins, ore cars, ore cans, concrete, lumber, composition, roofing, belts, air compressors, drills, pipe, cables, engine, boilers, conveyors and mill hardware. Estimated cost, \$65,000. Miss Emma Knell, secretary.

**BAXTER SPRINGS**—The Omaha Lead and Zinc Co., Joplin, Mo., will build a 250-ton concentration plant and is in the market for sludge, slime tables, engine, boilers, crushers, conveyors, mill hardware, air compressors, etc. Estimated cost, \$65,000. T. M. Chenoweth, superintendent.

**BAXTER SPRINGS**—The Mississippi Queen Mining Co. will build a 250-ton concentration plant and is in the market for sludge and slime tables, belts, lumber, roofing, crushers, engine, boilers, air compressors, mill hardware, conveyors, drills, etc. Estimated cost, \$65,000. W. H. Berry, superintendent.

**TREES**—The Montreal Chuff Mining Co. will build a 250-ton concentration plant on the coal line and is in the market for crushers, belts, wire cables, concrete, wheels, mill hardware, engine, boilers, roofing, air compressors, pipes, pumps, drills, etc. Estimated cost, \$65,000. C. F. Dyke, superintendent.

#### Louisiana

**NEW ORLEANS**—The Bureau of Yards and Docks, Navy Department, Wash., D. C., will build a shell house. Estimated cost, \$40,000.

#### Maryland

**HYATTSTOWN**—The Hyattstown Roller Mills will rebuild its plant recently destroyed by fire, entailing a loss of \$12,000. Mortier and Luhn, operators.

#### Massachusetts

**SPRINGFIELD**—The Hampden Paint & Chemical Co., 317 Main St., has awarded the contract for the construction of a factory addition to the Casper Ranger Construction Co., 20 Bond St., Holyoke. Estimated cost, \$5000.

#### Michigan

**DETROIT**—The General Aluminum & Brass Manufacturing Co., Boulevard and Aubion Sts., will build new units to its plant to include a 2-story, 100 x 100 ft., aluminum foundry, with concrete covers, two brass foundries, one 40 x 100 ft., to be equipped with sand bins and simplex and coke furnaces, the other, 60 x 180 ft., and a 3-story, 60 x 140 ft. machine shop. Government orders have made this addition necessary.

**GRAND RAPIDS**—The Semet-Solvay Co., Milton Ave., Syracuse, N. Y., has awarded the contract for the construction of a 1- and 2-story, reinforced concrete, brick and steel T.N.T. plant, covering 500,000 sq. ft., floor space, to Stone & Webster Co., 147 Milk St., Boston, Mass. Estimated cost, \$2,000,000. Noted Aug. 15.

**MIDLAND**—The city will install a water testing station and plans to install

a filter plant. S. A. Greeley, Schiller Building, Chicago, Ill., engineer.

#### Minnesota

**FAIRMONT**—The city will build a sewage disposal plant including an Imhoff tank and sludge drying beds. E. L. Lewis, city clerk.

#### Missouri

**AURORA**—Sharp & Co. will build a 150-ton concentration plant on Bonanza Lease, and is in the market for sludge and slime tables, crushers, air compressors, drills, belts, conveyors, concrete, lumber, and mill hardware. Estimated cost, \$45,000.

**AURORA**—Stanley & Co. will build a 1-ton concentration plant on Foster Lease, and is in the market for drills, hoists, sludge, tables, boilers and crushers. Estimated cost, \$45,000.

**DUENVEG**—The St. Louis Mining Co., 721 Main St., Joplin, will remodel its 150-ton concentration plant and is in the market for sludge and slime tables, small motors, engine, boilers, crushers, drills, conveyors, belts, mill hardware and roofing, etc. Estimated cost, \$25,000. J. Blair, superintendent.

**JOPLIN**—The Julian Mining Co. will build a 150-ton concentration plant south of Four Corners, and is in the market for sludge and slime tables, crushers, lumber, roofing, air compressors, drills, belts, ore cans, ore cars, engine, boilers, concrete, mill hardware, conveyors, etc. Estimated cost, \$45,000. Charles McDonald, superintendent.

**JOPLIN**—The Kansas Line Mining Co. will remodel its 200-ton concentration plant near Kansas State Line, and is in the market for sludge and slime tables, ore cans, lumber, roofing, mill hardware, crushers, air compressors, belts, drills, conveyors, engine, boilers, etc. Estimated cost, \$40,000. G. Meese, superintendent.

**KANSAS CITY**—The Talbot Reel & Manufacturing Co., 11th Ave. and 13th St., has awarded the contract for the construction of two factory buildings, one 2-story, 55 x 130 ft. and one 2-story, 69 x 130 ft., for the manufacture of sunights and binoculars, to Hoffman Bros., Ridge Building. Estimated cost, \$140,000.

**MANSFIELD**—The Mansfield Mining and Development Co. will build a 250-ton concentration plant and is in the market for sludge and slime tables, crushers, belts, drills, ore cans, ore cars, lumber, mill hardware, conveyors and air compressors. Estimated cost, \$65,000. J. R. Sardage, superintendent.

**RICHMOND**—The city will build a filtration plant. J. W. Kirkpatrick, city clerk.

**ST. LOUIS**—The Monsanto Chemical Co., 1500 South 2nd St., has awarded the contract for the construction of a 2-story, 80 x 110 ft. chemical factory, to Jas. H. Bright Contracting and Building Co., 706 Chestnut St. Estimated cost, \$118,000.

**WACO**—The Butler Bros. Mining Co. will build a 250-ton concentration plant, and is in the market for crushers, engine, boilers, lumber, concrete, ore cans, ore track, ore cars, mill hardware, sludge and slime tables, air compressors, pipe and conveyors. Estimated cost, \$65,000.

**WACO**—Frank Danclade will build a 250-ton concentration plant at his mine, and is in the market for sludge and slime tables, crushers, engine, lumber, mill hardware, concrete conveyors, rollers, composition roofing, engine, boilers and drills. Estimated cost, \$65,000.

#### Nebraska

**LINCOLN**—The Board of Regents, c/o J. S. Dales, secretary, Station A., will build a 2-story, 20 x 40 ft., pathology and hygiene building. Estimated cost, \$40,000.

#### New Jersey

**BAYONNE**—The Taintor Manufacturing Co., 1st St. and Lexington Ave., will make improvements and build an addition to its plant for the manufacture of whitening, etc. Estimated cost, \$50,000.

**HARRISON**—The Crucible Steel Co., Harrison, has awarded the contract for the construction of a 1-story, 88 x 120 ft., open hearth building, 1-story, 24 x 30 ft., shipping building, 1-story, 28 x 300 ft., ordinance building, 1-story, 10 x 18 ft., pump house and a 1-story, 10 x 40 ft., oil storage building, on South 4th St. and Ocean Road, to W. H. and F. W. Crane Woolworth Building, New York City. Estimated cost, \$125,000, plus percentage.

**JERSEY CITY**—The Interstate Chemical Co., 12 Bayview Ave., has awarded the contract for the erection of a 1-story, brick

factory and storage building on Garfield Ave. to Wm. R. Whyte, 36 Oakland Ave. Estimated cost, \$15,000.

**NEWARK.**—The Board of Education, City Hall, will build a 3- and 2-story, 250 x 250 ft. rectory and steel vocational school, including a chemical laboratory, on a site near Morris Canal. Estimated cost, \$50,000. L. Sonntag, City Hall, architect.

**NEWARK.**—The Linden Tanning Co. will build a 1-story, 60 x 60 ft. brick factory on Frelinghuysen Ave. Estimated cost, \$25,000. W. E. Lehman, 738 Broad St., architect.

**PAULSBORO.**—The Port Mifflin Ship-building Corporation, Widener Building, Philadelphia, Pa., will build a new ship-building plant to include a 1-story, 60 x 850 ft. plate shop, 1-story, 120 x 175 ft. plate shop, 1-story, 76 x 350 ft. forge shop, 1-story, 60 x 175 ft. copper shop, 2-story, 50 x 200 ft. paint works, 1-story, 100 x 530 ft., erecting shop and a 2-story, 100 x 530 ft., joiner shop. L. A. Gilliam, general manager.

## New York

**KINGS PARK.**—The State Hospital Commission, Capitol, Albany, has awarded the contract for the construction of extension to the hospital disposal plant at Kings Park. The disposal plant at Kings Park, Sewage Disposal Co., 37 East 28th St., New York City. Estimated cost, \$15,037.

**LYONS FALLS.**—Moyer & Pratt has awarded the contract for the construction of a 2-story, 100 x 105 ft. paper mill, to L. W. Charlebois, 541 Main St., Watertown. Estimated cost, \$50,000.

**SPRINGFIELD.**—The Semet-Solvay Co., Mill, has awarded the contract for the construction of a 100 x 200 ft., No. 3 Standard Building, to the Austin Co., 16112 Eucha Ave., Cleveland, O. Estimated cost, \$75,000.

**TOMPKINSVILLE.**—The Bureau of Yards and Docks, Navy Dept., Washington, D. C., will build a laboratory and office building here. C. O. Parks, chief.

## North Dakota

**FARGO.**—The Board of Education, E. Guthrie, clerk, has awarded the contract for the construction of a 3-story, brick and concrete high school to include laboratory. B. H. Heston, City Hall, 716 South 11th St., Minneapolis, Minn. Estimated cost, \$215,000.

## Ohio

**CANTON.**—The Canton Sheet Steel Co. will build an addition to its steel mill to include machine shop, forge shop and rolling mills. Estimated cost, \$75,000.

**CANTON.**—The Timkin Roller Bearing Co., Leubster St., will build a 1-story, 100 x 250 ft. concrete, brick and steel factory. Estimated cost, \$80,000.

**DELAWARE.**—The K. & W. Rubber Co., c/o Ora Keichbaum, Ashland, will build a 2-story, 100 x 200 ft. brick and steel factory, for the manufacture of rubber. Estimated cost, \$75,000.

**CLEVELAND.**—The Boro of New Brighton, New Brighton, Pa., will build a brick and reinforced concrete sewage disposal plant. Estimated cost, \$60,000. R. V. Pratt, 708 Hippodrome Building, engineer.

**CLEVELAND.**—The Hughes-Keenan Co., 260 North Main St., Mansfield, has purchased an acre site and will build a factory for the fabrication of steel here. The company recently increased its capital stock from \$25,000 to \$80,000.

**CLEVELAND.**—The Lake Erie Smelting & Refining Co., 7900 Bessemer Building, has awarded the contract for the construction of a 2-story, 40 x 54 ft., reinforced concrete and steel factory at 7900 Bessemer St., to Riley Construction Co., 806 Leader-News Bldg. Estimated cost, \$15,000.

**LORAIN.**—The Cleveland Macadam Co., 1040 Leader-News Bldg., will build a steel and brick plant and shipyard. Estimated cost, \$50,000.

**SANDUSKY.**—The Ohio Tread & Tire Co. has awarded the contract for the construction of a 2-story, 40 x 80 ft., reinforced concrete and brick factory, to Wm. Dorthach & Bros., Sandusky. Estimated cost, \$20,000.

## Oklahoma

**GARDIN.**—The Amy T. Mining Co., Miami, will build a 300-ton concentration plant, and is in the market for sludge and slime tables, ore cars, crushers, belts, lumber, concrete, mill hardware, air compressors, track, gas engine, boilers, steam engine, wire and cables. Estimated cost, \$65,000. J. Buckley, superintendent.

**GARDEN.**—The Shelton Mining Co. will build a 250-ton concentration plant, and is in the market for boilers, drills, sludge and mining machinery, mill hardware, crushers, belts, etc. Estimated cost, \$65,000. F. Childers, superintendent.

**HOCKERVILLE.**—The Lucky Jennie Mining Co., Miami, Okla., will build a 300-ton concentration plant, and is in the market for electric motors, boilers, engine, belts, slime tables, crushers, air compressors, drills, mill hardware, roofing, conveyors, etc. Estimated cost, \$65,000. G. Sullivan, superintendent.

**HOCKERVILLE.**—The St. Louis Smelting and Refining Co., Baxter Springs, Kan., will build a 250-ton concentration plant, and is in the market for sludge and slime tables, ore cars, crushers, air compressors, conveyors, etc. Estimated cost, \$65,000. R. B. Kropp, superintendent.

**HOCKERVILLE.**—The Union Mining Co. will remove and remodel its 200-ton concentration plant, and is in the market for two electric motors, sludge and slime tables, mill hardware, concrete, roofing, air compressors, drills, pipe and crushers. Estimated cost, \$25,000. Robert Qualls, superintendent.

**MIAMI.**—The Amalgamated Co. will build a 250-ton concentration plant, and is in the market for sludge and slime tables, motors, engine, boilers, crushers, lumber, mill hardware, concrete, roofing, conveyors, drills, wire cables, ore cans and cars. Estimated cost, \$65,000. H. L. Huddston, Webb City, Mo., superintendent.

**MIAMI.**—The Atoka Mining Co. will build a 300-ton concentration plant near Rob White lease, and is in the market for sludge tables, gas engines, crushers, compressors, drills, belts, conveyors, etc. Estimated cost, \$65,000. E. M. Applegate, superintendent.

**MIAMI.**—The Miami Metal Co. will build a 200-ton concentration plant near Picher, and is in the market for electric motor, gas engine, air compressors, belts, mill hardware, mill lumber, crushers, sludge and slime tables, etc. Estimated cost, \$65,000. R. Sadler, superintendent.

**MONARCH.**—The Vanwisser and Warren Co. will build a 250-ton concentration plant, and is in the market for mill hardware, engine, boiler, sludge and slime tables, crushers, conveyors, etc. Estimated cost, \$65,000. J. Warren, superintendent.

**MUSKOGEE.**—The Gasomne Co. will build a gasoline refinery. J. T. May, president.

**PICHER.**—The Golden Rod Mining Co. will build two 250-ton concentration plants, and is in the market for motors, engine, boilers, crushers, sludge tables, air compressors, drills, mill hardware, mill lumber, pipe, roofing. Estimated cost, \$65,000. G. Smoyer, superintendent.

**PICHER.**—The LaSalle Mining Co., Joplin, Mo., will remodel its 250-ton concentration plant, and is in the market for pumps, piping, belts, roofing, sludge tables, cement, lumber, drills, conveyors, crushers, air compressors, etc. Estimated cost, \$20,000. A. E. Eadelaar, superintendent.

**PICHER.**—The Mogul Mining Co., Miami, will build a 250-ton concentration plant, and is in the market for sludge and slime tables, drills, engine, boilers, roofing, lumber, concrete, crushers, air compressors, drills, wire cables, conveyors, ore cans, ore bins, ore cars and track. Estimated cost, \$65,000. A. E. Dunlap, superintendent.

**POTEAU.**—The city will build a filtration plant. C. M. Bagwell, mayor.

**TATUMS.**—The Ardmore Lubricating Oil Co. will build a refinery here and sink test well for oil.

**WALTERS.**—The Blue Ribbon Oil & Refining Co. will build a refinery; capacity, 1000 barrels.

## Pennsylvania

**CHESTER.**—The American Steel Foundries, 30 Church St., New York City, has awarded the contract for the construction of a 1-story, 25 x 60 ft., addition to its foundry at Thurlow Station, near Chester, to R. H. Scroggins & Son, Crozer Bldg.

**GLENSHAW.**—The Pittsburgh Mining Machinery Co., 1st National Bank Building, Pittsburgh, will build a 1-story, 65 x 80 ft., addition to its plant. Estimated cost, \$15,000.

**MARCUS HOOK.**—The National Aniline & Chemical Co. has awarded the contract for the construction of a 2-story, 106 x 196 ft., No. 9 type, modified building, to the Austin Co., 16112 Eucha Ave., Cleveland, O. Estimated cost, \$140,000.

**PHILADELPHIA.**—Baugh & Sons Co., 20 South Delaware St., will build a 1-story,

100 x 300 ft. addition to its plant on Morris St., for the manufacture of chemicals.

**PHILADELPHIA.**—The Fibre-Graphite Manufacturing Co., 34 South 17th St., will make alterations and improvements in its plant on Wakenfield St. Estimated cost, \$5000.

## Rhode Island

**WOONSOCKET.**—The Star Carbonizing Co. will build a 2-story, 52 x 178 ft. brick factory on Diamond Hill road. Estimated cost, \$45,000. W. F. Fountain, North Main St., engineer.

## Texas

**CARLSBAD.**—The Board of Directors, State Tuberculosis Sanatorium, has awarded the contract for the construction of a sewage disposal plant and sewer extensions, to Pault & Campbell, Dallas. Estimated cost, \$23,000.

**TEMPLE.**—The city will build an additional unit at sewage disposal plant. Estimated cost, \$7500. Address The Mayor.

**WACO.**—The city will install a settling basin at filtration plant. Estimated cost, \$26,811. E. L. Fulkerson, manager of city water works.

**WICHITA FALLS.**—J. A. Fisher and others will build an oil refinery, daily capacity 1000 barrels.

## Washington

**SEATTLE.**—C. L. Glasgow, New York City, has awarded the contract for the construction of a 1-story, 61 x 17 ft. construction plant for the manufacture of oxygen gas and welding appliances, on East Marginal Way and Spokane St., to James Clark & Sons, 1000 First St., Alaska Building. Estimated cost, \$50,000.

## Wisconsin

**CABLE.**—The Sunbeam Chemical Co., 1742 Ogden Ave., Chicago, Ill., is building a 75 x 300 ft. factory here, and will add other units later.

**CARROLLVILLE.**—The American Tar Products Co. has awarded the contract for the construction of a 1-story, 60 x 90 ft. factory, to Meredith Bros., 1043 Kinnickinnick Ave., Milwaukee. Estimated cost, \$20,000.

**GREEN BAY.**—The Northwestern Engineering Co., Inc., has awarded the contract for the construction of a 30 x 32 x 160 ft. addition to its fabricating plant, to L. Hanson. Estimated cost, \$80,000.

**MILWAUKEE.**—Becker Bros., 1118 26th St., has awarded the contract for the construction of a 3-story, 64 x 147 ft., brick and mill construction tannery, to Riesen Bros., 1st National Bank Building.

**MILWAUKEE.**—J. Schlitz Brewing Co., 3rd and Galena Sts., has awarded the contract for the remodeling of its carbonic gas plant, to W. Woefflein, 86 Michigan St.

## Canada

## Ontario

**ELMIRA.**—The Elmira Rubber Co. will build an addition to its plant. Estimated cost, \$30,000.

**WALKERVILLE.**—The Walkerville Water Co., Sandurich St., will install a 7,000-gal. tank. Estimated cost, \$250,000. C. D. Brown, 86 Lincoln Road, secretary.

**WELLAND.**—The Dillon Alloys Co., Ltd., 122 Hellens Ave., has awarded the contract for the construction of a 1-story, melting building, forge shop, boiler house, etc., to the Standard Steel Construction Co., Port Robinson. Estimated cost, \$150,000.

## Industrial Notes

**THE HALCOMB STEEL CO.** has opened an office in Room 702, Connecticut Mutual Life Insurance Bldg., 36 Pearl Street, Hartford, Conn. Mr. E. L. Keed will be in charge.

**THE QUIGLEY FURNACE SPECIALTIES CO.**, New York, has secured contract for a powdered coal plant from the Whitaker Glassing Company, Beckwith Bottom Works, West Virginia, to furnish 4 tons of powdered coal fuel per hour to supply 20 furnaces for heating 6-in. shell forgings. This equipment is necessary for larger extensions for future applications in other departments in the mills including boilers.

**THE ELECTRIC FURNACE CO.**, Alliance, Ohio, has opened a New York office at 15 Park Row. Mr. D. B. Mills is in charge.

**THE BOARD OF DIRECTORS OF THE MARDEN, ORTH & HASTINGS CORP.** held a meeting on Aug. 28 at which Mr. Arthur C. Trask was



lected vice-president of the Corporation with headquarters in Chicago. Mr. Trask's resignation as secretary of the Corporation was accepted, and Mr. Walter O. Hastings was elected to this office. Mr. Trask has been seventeen years with the concern. While Mr. Hastings is one of the three members of the partnership which in 1906 took over the business founded by James A. Murdock in 1837. Mr. M. S. Orth, President of the Corporation, is a direct descendant of Mr. M. S. Orth. Within the last few weeks Marden, Orth & Hastings have opened new branches at 1303 Shelby Street, Louisville, Ky., and Union Trust Building, Cincinnati, Ohio.

THE CUTLER-HAMMER MFG. CO., Milwaukee, Wis., announcing the opening of Sept. 3 of a branch office in the Union Trust Building, 15 & H Streets, N. W., Washington, D. C. Messrs. H. W. Knowles and C. W. Yerger will be located at the new office.

## New Publications

THE MACHINERY UTILITIES CO., INC., 501 Fifth Ave., New York City: A bulletin, which is only a general industrial equipment, entitled "The Thrift Book," devoted to the utilization of idle machinery in active industries.

THE DOW CHEMICAL COMPANY, Midland, Mich.: A booklet entitled "Dow Chemicals."

CONCRETE IN ARCHITECTURE AND ENGINEERING, Vol. No. 1, dated Jan. 1918, published bi-monthly by the Portland Cement Association, 111 West Washington St., Chicago, Ill. This Association has also published a booklet on "Concrete Tanks for Oil Conservation."

THE UNCOLORED STORY OF AMERICAN DYES. By John Walker Harrington. This appeared in the Evening Post Magazine, May 11, 1918, and has been reprinted in booklet form by the National Aniline & Chemical Company, Inc., 21 Burling Slip, New York City.

BUILDING CONSTRUCTION. By R. I. Webster. Bulletin No. 25, Vol. XIII, No. 1, dated January, 1918, issued by The Pennsylvania State College's Engineering Experiment Station, reprinted from the Annual Report for 1916-1917.

SCHOOL OF MINES AND METALLURGY, Univ. of Missouri, Rolla, Mo. Bulletin, March, 1918, Vol. 10, No. 2, which is the 1917-1918 catalog.

THE EVOLUTION OF NATIONAL SYSTEMS OF VOCATIONAL REEDUCATION FOR DISABLED SOLDIERS AND SAILORS. Bulletin No. 15, (Reeducation Series No. 3). By Douglas MacMurtrie, issued by the Federal Board of Vocational Education, May, 1918.

REFERENCE MATERIAL FOR VOCATIONAL AGRICULTURAL INSTRUCTION. Bulletin No. 14, Agricultural Series No. 2, issued for the Federal Board of Vocational Education, Washington, D. C.

CASE-HARDENING, issued from the Carnegie Library of Pittsburgh, reprinted from the monthly bulletin, March, 1918.

STANDARD LABORATORY TESTS OF COAL- COKE BYPRODUCTS, issued by the Scientific Materials Company, Pittsburgh, Pa., dealing with acid-wash tests for benzol, boiling-point determinations, coal and coke examinations, apparatus for gas examination, specific gravity, density, size analysis, separating apparatus for light-oil, wash-oil and tar testing and tar-special apparatus for tar testing. This booklet contains 32 pages and is well illustrated.

MONTHLY REVIEW OF THE U. S. BUREAU OF LABOR STATISTICS. Vol. VI, June, 1918, No. 6, issued by the U. S. Department of Labor, Bureau of Labor Statistics, Washington, D. C.

THE BULLETIN, Vol. V, No. 11, Series of 1918, published by the Pennsylvania Department of Labor and Industry, Harrisburg, Pa.

NEW U. S. GEOLOGICAL SURVEY PUBLICATIONS: Platinum and Allied Metals in 1917. By James M. Hill. (Pages 1-21, Mineral Resources, 1917, Part I), published June 21, 1918. Gems and Precious Stones in 1917. By Waldemar T. Schaller. (Pages 887-899, Mineral Resources, 1917, Part I), published June 27, 1918. Bauxite and Aluminum in 1917. By James M. Hill. (Pages 1-9, Mineral Resources, 1917, Part I), published June 27, 1918. Strontium, Barium, Lithium, Selenium, and Tellurium in 1917. By Joseph B. Umpleby. (Pages 23-35, Mineral Resources, 1917, Part I), published June 27, 1918. Strontium, Barium, Lithium, Selenium, and Tellurium in 1917. By James M. Hill. (Pages 5-6, Mineral Resources, Part II), published June 19, 1918. Gold and Silver in 1916 (General Report). By H. D. McCuskey and J. P. Dunlop.

Pages 679-721, (Mineral Resources, 1917, Part I), published May 7, 1918. Fuel Briquetting in 1917. By E. J. Leeger. (Pages 1-11, Mineral Resources, 1917, Part I), published May 6, 1918. Cadmium in 1917. By C. E. Siebenthal. (Pages 49-53, Mineral Resources, 1917, Part I), published July 12, 1918. Sulphur, Pyrites, and Sulphuric Acid in 1917. By Philip S. Smith. (Pages 19-62, Mineral Resources, 1917, Part II), published July 10, 1918.

NEW BUREAU OF STANDARD PUBLICATIONS: Bulletin, Vol. 14, No. 1, being a collection of scientific papers on determination of degrees of purity of bright metals for magnetic standards; thermoelectric measurement of critical ranges of pure iron; study of electromagnet moving coil galvanometers for use in alternating current measurements; standard substances for calibration of viscometers, an "average eye" for heterochromatic photometry, and comparison of flicker and equilibrium of bright metal photometer, emissivity of straight and helical filaments of tungsten; aneroid calorimeter for specific and latent heats; and wave lengths of strong lines in helium spectrum. Scientific Paper 32. Application of Dicyanin to Photography of Stellar Spectra. By Paul W. Merrill. Technologic Paper No. 103. Glass for Protection of Eyes from Injurious Radiations. By W. W. Boblentz and W. B. Emerson. Technologic Paper No. 107. Comparative Test of Chemical Glassware. By T. H. Walker and F. W. Fisher. Circular No. 13. Standard Specifications for Incandescent Electric Lamps. Technologic Paper No. 101. Tests of Large Bridge Columns. By J. H. Griffith and C. G. Francis. Circular No. 12. Price, \$0.30. Technologic Paper No. 113. Determination of Permeability of Balloon Fabrics. By Julius David Edwards, issued June 2, 1918. Paper No. 114. Technologic Paper No. 323. Some Characteristics of the Marvin Pyrhellometer. By Paul D. Foote, issued June 28, 1918. Price, \$0.10. No. 74, entitled "Copper" issued June 25, 1918. Price, 20 cents, sold through the Superintendent of Documents, Government Printing Office, Washington, D. C.

NEW BUREAU OF MINES PUBLICATIONS: Bulletin 164, Law Serial 14, Abstracts of Current Decisions on Mines and Mining. Reported from September to December, 1917. By J. W. Thompson. Technologic Paper 184, Weights of Various Coals. By S. B. Flagg. Technologic Paper 189, Temperature-Viscosity Relations in the Ternary System of Oil-Alcohols. By Alexander Field and P. H. Royster. Technologic Paper 144. The Quick Determination of Incombustible Matter in Coal and Rock-Dust Mixtures in Mines. By C. Fieldner, 1917. By J. W. Thompson. Technologic Paper 102, Mining and concentration of carnotite ores. By K. L. Kithil and J. A. Davis. Bulletin 140, Occupational Hazards in the high pressure plants of the convention, based on records of accidents at blast furnaces in Pennsylvania in 1915. By P. H. Wilcox. Bulletin 155, Oil-storage tanks and reservoirs, with a brief discussion of losses of oil in storage and methods of prevention. By C. P. Bowie. Technologic Paper 170. The diffusion of oxygen through stored coal. By S. H. Katz. Technologic Paper 172. Effects of moisture on the spontaneous heating of stored coal. By S. H. Katz and H. C. Porter. Technologic Paper 191, Report of the Committee on the Standardization of Mining Statistics. Compiled by Albert H. Fay.

THE JONATHAN BARTLEY CRUCIBLE CO., Trenton, N. J., issue a well illustrated and instructive booklet on Graphite Crucibles for Foundry Practice.

MICHIGAN COLLEGE OF MINES, Houghton, Mich.: Year Book, 1917-1918. Announcement of courses for 1918-1919.

SOUTH DAKOTA STATE SCHOOL OF MINES, Rapid City, South Dakota, April, 1918: Annual catalog 1917-1918, with announcements for 1918-1919.

NEW U. S. DEPARTMENT OF THE INTERIOR BULLETIN: Mineral Resources of the United States in 1917. Part I. By James M. Hill. 1917. By C. E. Siebenthal; 6, "Gold, Silver, Copper, Lead and Zinc in the Eastern States in 1917," by James M. Hill. Part II. By James M. Hill. Pyrites and Sulfuric Acid in 1917," by Philip S. Smith; 5, "Magnesia in 1917," by Charles G. Gale and Ralph W. Stone; 6, "Talc and Soapstone in 1917," by D. L. Dyer; 7, "Graphite in 1917," by Ralph W. Stone; 8, "Graphite in 1917," by Henry C. Ferguson; 13, "Mica in 1917," by Waldemar T. Schaller.

THE HORTON INDUSTRIAL DIGEST is the new publication of E. F. Houghton and Co., Philadelphia, Pa., dated August, 1918. This publication will be issued every month.

one issue will deal with "textiles" and the next issue with "metal working," etc.

THE EFFECT OF ADDITION AGENTS IN FLOTATION. A bulletin dated Nov., 1917, from the School of Mines and Metallurgy, Rolla, Mo. Most of the material in this bulletin appeared in METALLURGICAL AND CHEMICAL ENGINEERING, in the Dec. 15, 1917, Jan. 15, 1918, and Mar. 1, 1918, issues.

"FUEL FACTS" is the name of a new publication published by the United States Fuel Administration, Washington, D. C. This is dated Aug. 1, 1918.

"TUNGSTEN" is the title of an attractive illustrated booklet issued by the TUNGSTEN PRODUCTS MINING CO., Boulder, Colo.

"THE GLASS INDUSTRY AS AFFECTED BY THE WAR" is the Tariff Information Series—No. 5, issued by the United States Tariff Commission, Washington, D. C., and deals with new branches of the industry, changes in manufacture and trade due to war conditions, holding export and domestic trade after the war, the glass trade of European countries, and testimony of leading American manufacturers.

ANALYSIS OF CANADIAN FUELS. Compiled by Edgar Stansfield and J. H. H. Nicolls. Bulletin No. 23 issued by the Canadian Department of Mines, Ottawa, Canada.

NEW BUREAU OF MINES PUBLICATIONS: Bulletin 145, Measuring the temperature of gases in boiler settings. By Henry Kreisinger and J. F. Barkley. Technologic Paper 187. Slag viscosity tables for blast-furnace work. By L. L. Felt and F. H. Royster. Bulletin 123, Analyses of mine and car samples of coal collected in the fiscal years 1913 to 1916. By Arno C. Fieker, Howard L. Smith, J. W. Paul and Samuel Sanford. Technologic Paper 91. A convenient multiple-unit calorimeter installation. By J. D. Davis and E. L. Wallace. Monthly statement of coal-mine production in the United States for 1918. Compiled by Albert H. Fay. This booklet gives a list of permissible explosives, lamps, and motors tested prior to June 30, 1918. Price, \$0.05.

## Manufacturers' Catalogs

THE CHICAGO BELTING CO., Chicago, Ill., has issued an attractive catalog entitled "To Users of Belting" which contains 80 pages, giving views of its plant and a brief description of the various processes used in making belting.

UNITED IRON WORKS CO., Kansas City, Mo.: Bulletin No. 418, describing and illustrating Pomona duplex journal power pumps.

THE GILBERT & BARKER MFG. CO., Springfield, Mass.: Catalog B illustrating and describing its different types of gas furnaces. This company's process for burning fuel oil under low pressure.

THE TORSION BALANCE CO., New York City: Catalog No. 34 on "Torsion Balance," illustrating the many different balances.

THE HYDRAULIC PRESS MFG. CO., Mount Gilead, Ohio: Catalog No. 43 which describes and illustrates H-P-M hydraulic valves and fittings, hydraulic presses, pumps, accumulators and intensifiers for every high-pressure purpose.

THE DUST RECOVERING & CONVEYOR CO., Cleveland, Ohio, calls attention to Bulletin No. 5, August 1, 1918, on pneumatic conveying.

T. SHRIVER & CO., Harrison, N. J., has issued an attractive catalog on filter presses for all purposes. The catalog contains 44 pages and is well illustrated.

LEEDS & NORRUPH CO., 4901 Stenton Ave., Philadelphia, Pa. Catalog 87, entitled "The Potentiometer System of Pyrometry and Temperature Control," contains 60 pages and is illustrated with half-tones and charts. This catalog deals with potentiometer indicators, curve draw-ers, recorders, multiple point readers, temperature control apparatus, transformation point apparatus, precision potentiometers, thermocouples and optical pyrometers.

THE PYROELECTRIC INSTRUMENT COMPANY, 636 East State Street, Trenton, N. J., calls attention to Circular No. 11 on the Northrup-Ajax High Frequency Induction Furnace which are available in small units for laboratory and scientific investigations.

THE EASTMAN-BLESSING COMPANY, W. Austin Ave. at La Salle St., Chicago, Ill., has issued a catalog on Rego welding and outting apparatus, which gives prices of apparatus.



# CHEMICAL & METALLURGICAL ENGINEERING

A consolidation of ELECTROCHEMICAL & METALLURGICAL INDUSTRY and IRON & STEEL MAGAZINE

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### The Chemical Exposition and Our Daily Service

At the moment we can think of no industry other than the chemical that could focus attention for a week in war time on a national exposition held in the country's metropolis. It signifies a growing appreciation of the fundamental and basic importance of chemistry in industry and the arts. It is not too much to say that preparations for the event have been under way for a year, for with the closing of each exposition there has been a general reservation of space for the next, and only a short respite before actual plans have been laid for the exhibits themselves.

This year a further tribute to the importance and great public value of the Exposition was paid by the action of the Government itself in permitting the management to proceed with the arrangements in spite of the fact that the great building in which the exposition is held has been commandeered for a military hospital and is undergoing alterations while the show is in progress. Probably no manufacturers in the country are busier than those in the chemical and metallurgical industries. Their time and their products are precious. Labor is scarce and transportation expensive. And yet in spite of all these unnatural drawbacks, busy men have found time to prepare exhibits that are at once interesting to the layman and instructive to the technologist; railroads have transported tons of machinery and material; and the tangible evidence of America's approach to chemical leadership and industrial independence is gathered together in one vast "Exhibit A."

To fail adequately to preserve a record of such an achievement and reflect to the country at large the growing greatness of our chemical industry would be a misfortune indeed. The Exposition would most nearly fulfill its purpose if it could be produced in every important industrial center in the country. This being obviously impossible, it remains for some agency to carry the Exposition to the people, reflecting its activities and reporting its daily proceedings as a tremendous educational force.

Realizing that the full story could never be told in a single issue of this journal, and sensing the need for a timely exponent of the Exposition, we decided to render the service through a series of five daily magazines in which should be expressed some of the prominent phases of our chemical industry. These are identical with the topics for the daily symposia at the Exposition, and comprise: Dyestuffs, explosives and acids; potash; ceramics; metal industries; and industrial organic chemistry. On the subject of explosives we cannot present as much material as we would like, for obvious reasons, but the issue will contain some up-to-date information.

Potash independence is a vital matter to the United States and in the daily devoted to that subject we present what we believe to be the most complete symposium yet compiled. The story of the development of the ceramic industries likewise is typically American and wonderfully encouraging. In metals and alloys we have long held high rank, but the war has stimulated endeavor and produced some new achievements which we record. Finally in organic chemistry in the arts and industries, we recognize a phase of growing importance, and in the issue for Oct. 1 will be found a variety of evidence of this fact. On the whole, the series will constitute a service unparalleled in the records of chemical journalism, but one that is fully justified by the unusual conditions demanding it.

### Statistics of the Chemical Industry

Statistics are notoriously unpopular, so much so that speakers always apologize for inflicting them on an audience, and writers refrain from reference to them except in case of urgent necessity. Statistics also are the subject of a certain type of joke, which will readily come to mind, because like isolated passages from the Scriptures, almost anything can be proved by them; also they are grossly referred to as a form of prevarication.

However these things may be, we make no apology for devoting our first Exposition Daily to consideration of the economic, financial and business side of the chemical industry, with a number of pages devoted to its statistical features. There are several reasons why we consider such a presentation timely and sufficiently important to warrant a special issue.

In the first place, intelligent participation in an industry, particularly one that is expanding as rapidly as the chemical industry, requires more than guesswork when it comes to basing future hopes on past performance. Ask almost any small manufacturer what he knows about the production, imports, exports, sources of supply, market for products and general economic conditions in his industry, and we venture to say his reply will show a general, though not necessarily profound, ignorance of the fundamental facts. On the contrary, let a well-managed manufacturing corporation contemplate a new departure in its business, and again we venture the assertion that before reaching a decision it will have studied the despised statistics carefully to see whether the venture is worth while and offers a reward commensurate with the required risk.

Submit the essential economic facts of an industry to analysis and you will have statistics as an important residue after the more volatile and less important elements have been distilled. As basic facts you will have some expression of quantity and value which will measure the importance of the industry for you. Compare and analyze the residue and you will gain information not otherwise obtainable.

The only statistical yard-stick we have for our chemical industry is the census of manufactures for 1914. Although the figures are readily obtainable they are not widely distributed and used. Believing that they should afford a basis for many a sound business survey during these years of expansion, we bring them to the attention of the chemical industry feeling that the effort is warranted once in five years.

Another feature in this issue is an analysis of the chemical industry by the economist and statistician of a great financial and business institution. Banks are following the chemical industry closely, both in its domestic and foreign aspects. A special contributor deals with the latter phase of the industry. No less important is the announcement of the work undertaken by the American Chemical Society to give us adequate information on our imports of raw materials for the chemical industry, as well as finished products. The ultimate achievement of the ambitious plans which the Society has laid out will be worthy of the largest chemical society in the world, in what we firmly believe will become the greatest chemical nation in the world.

### Wanted: Public Appreciation of the Chemical Industry

One of the greatest functions of the chemical exposition, particularly in this fifth year of the war, is the education of the general public to a proper appreciation of the importance of chemistry in our national life. If there were no other benefits to be derived; if chemists themselves and their technically trained colleagues gained nothing through inspection of the exhibits and listening to learned discussions; if the industry did not profit in a material way from the efforts expended in the great show; if none of these things resulted, the time and labor involved would still be well spent if the people of the United States would begin to think of our nation in terms of chemistry.

We do not mean to inflict the technical language of the profession on the public, but we do mean that there should be more than a slight comprehension of the fact that chemistry lies at the bottom of industrial independence, and that for the future welfare of our people we must recognize this fact and give it support in matters pertaining to education, legislation, economics and politics. We mean that the public should see to it that the chemist as an individual citizen plays a more important part in our affairs; that he is consulted in matters affecting our national life; that he is even forced out of the retirement of his laboratory and made to function in the body politic.

It has been said in extenuation of the chemist's failure to play a more prominent part, that his work is best done in retirement and seclusion and that he acquires a habit of modesty that prevents him assuming a public rôle. But if the chemist has been backward and modest, his shortcomings are as nothing compared with the failure of public appreciation of his work. Nor is this a new story; it is as old as chemists and chemistry. Elsewhere in this issue we reproduce the words of a wise man of Philadelphia who told his colleagues one hundred and twenty years ago that the United States could never achieve true independence until chemistry played a large part in the country's development. This was spoken but a few years after the revolutionists had thrown off the rule of the mother country and had assumed the rôle of an independent nation. Political independence was a prize worth fighting for, but it required the vision of a chemist to foretell the futility and weakness of an independence not founded on the rock of chemistry. What chemists want today as then, is a public support and appreciation of the fact.

# Opening Exercises at the Chemical Exposition

## Verbatim Report of Addresses Made by Leaders of the Chemical Industry Touching on Important Public Problems

THE Fourth National Exposition of Chemical Industries was formally opened to the public Monday afternoon, Sept. 23, 1918. The event was signalized by the gathering of a notable body of men who are devoting their time to the application of chemistry in the cause of democracy. The chemical societies were represented by their presidents with the exception of Dr. William H. Nichols, President of the American Chemical Society, who was unable to attend. We present herewith, practically in full, the remarks of the principal speakers.

### Permanent Chemical Independence

BY CHARLES H. HERTY  
Chairman Advisory Committee

THIS annual assemblage of the products of American chemical industry and of the mechanical appliances by which these products are manufactured provides fitting occasion for a stock-taking of past accomplishments, and a care-taking for the perman-



CHARLES H. HERTY

understanding is produced which creates a sound, intelligent public opinion, which is the greatest asset any industry can possess.

The number of exhibitors continues to grow, in keeping with the continued expansion of the industry throughout the nation. The only disappointment is the setting aside by the Railroad Administration of the large plans which had been inaugurated by the industrial departments of the several railroads for presenting here a marvelous display of those natural resources of this country which still await the touch of the chemist to rise to their true dignity as invaluable assets. It has been deemed necessary to eliminate during war times this most promising and well inaugurated line of development.

In taking stock of the chemical industry first thought turns naturally to the matter of available capital. The amount of capital accessions has continued to grow. During the first eight months of 1918, \$59,164,000 was added, making the aggregate authorized capital invested in the industry since August 1, 1914, the date of the outbreak of the war, \$386,967,000.

These figures do not include, of course, the investments made by the national Government in the great chemical plants whose output is used solely for war purposes. The total production of these plants sets our Government apart as the largest manufacturer of chemicals in the world. In the after-war period when the story may be told of the rapidity of construction and of the enormous output of these plants it will add a brilliant chapter to the romance of chemistry. Meanwhile we can rest content in the assurance that the great army which we are now hurrying to Europe will be abundantly supplied.

Perhaps the picture of the growth of the industry can best be gathered from a few figures concerning our export trade, for export statistics indicate production in excess of domestic needs, great as these demands have been during the past year. Four items have been selected, three because of their fundamental character, and one on account of the rapidity of its development.

| Exports                      | 1913/1914      | 1917/1918       |
|------------------------------|----------------|-----------------|
| Sulphuric acid               | 12,000,000 lb. | 68,000,000 lb.  |
| Caustic soda and soda ash    | negligible     | 334,000,000 lb. |
| Benzol                       | negligible     | 25,000,000 lb.  |
| Dyes, dyestuffs and dyewoods | \$357,000      | \$17,000,000    |

Doubtless in future years these figures will appear diminutive, but at present they constitute an inspiring hope for that future.

A fair measure for that increasing participation of the Government in chemical activity is shown in the supplemental appropriation estimates submitted by the War Department to Congress on September 17, 1918. Aside from the great appropriations for explosives there has been requested for the Chemical Warfare Service, the recently organized division having to do solely with offensive and defensive gas warfare, \$198,-

ency of those additions to our national wealth whereby economic independence may be assured. To secure this independence it is essential that there should be close cooperation between the chemist and the American people, which can only be brought about when the chemist takes the people into his full confidence regarding the problems whose successful solution is a matter of joint responsibility. By the presentation of these exhibits and by open discussion of the problems confronting the industry a sympathetic



704,000, a sum greater than was asked for the clothing of the increased army we are now raising. Germany began poison gas warfare; within the next twelve months it will have more than its fill of it.

#### PUBLIC SUPPORT

The present status of the American chemical industry and its prospect for the future must prove gratifying to all good citizens of this republic, but these prospects can never be fully realized unless the work of the chemist is supported by sound and loyal public opinion, which, in turn, will eventually manifest itself in the form of a thoroughly sympathetic attitude on the part of official representatives of that public opinion.

The stress of war preparations and the great part we feel that we are destined to play in the decision have aroused a wholesome national pride, which should contribute to the development of an atmosphere of good-will. America must make good! America can make good! America shall make good! These thoughts fill the minds of our people to-day. The craze for "imported goods" which has so often palsied industrial effort is now being supplanted by pride in domestic achievement. Certainly the label "Made in Germany" no longer exerts its hypnotic influence over the masses of the world. Yet German propaganda is insidious, is ever present, and must constantly be combatted if we are to gain that measure of national self-containedness in essential industries which will guard us against a recurrence of the economic tribulations which characterized the period immediately following the blockading of German ports. The chief centers of that disturbance were coal-tar chemicals (dyes and medicinals), and potash; and I beg to ask your serious attention to certain conditions attending the efforts to create these industries in this country.

#### DYES AND GAS WARFARE

No word is needed concerning the marvelous development of the dye industry. It is here to-day for your inspection. Nor need I dwell upon the close relation of this industry to that of high explosives. That point has already sunk deep into our national consciousness. It was appreciation of this relation perhaps even more than economic need, which brought together producers and consumers in a unique display of unanimity which procured from Congress a protective tariff and anti-dumping legislation which guaranteed life for the young industry.

There was an additional argument for such legislation, however, undreamed of by any of us at that time. We had not entered the war, and gave no thought to the efforts which might be required of us in the matter of poison gas production. But when our authorities, following our entrance into the war, determined to meet the Germans with their own weapons and on a scale far greater than they had ever contemplated, it became necessary to make use of every available means for manufacture of toxic material. The great plants planned for government construction and operation were not sufficient for the program. I am violating no confidence in telling you that at this juncture the Government turned to the young dye industry for plants and trained organiza-

tions to augment its poison gas output, and splendidly has the young industry responded. For military reasons I am advised not to mention specific plants or the products manufactured therein, but with official sanction I may say that five dyestuff plants are now participating in the production of this material, while many others are contributing indirectly to the same end. The plants were suited to the needs, staffs and workmen were familiar with this kind of work, and the process of conversion to the new rôle was thus enabled quickly to be made.

In view of the adaptability of the dyestuff industry to such serious national needs, it is difficult to be patient with many of our mercantile establishments which still insist upon placarding their counters with signs such as "The color of these goods cannot be guaranteed." What a sweet morsel of comfort these placards are to the enemy, in effect an effort to preserve the market for him, by our own people, if such they are! Was it ever the practice to guarantee all colors? Certainly not, for even before the war nine-tenths of the dyes used were not fast and did not need to be. Moreover, are our merchants not yet aware of the conditions which led for a time to the uncertainties as to color fastness? Do they not know that in the period of acute shortage of German dyes, before the American industry was started, many German dyes were used for purposes never intended, and so gave bad results, in most cases falsely attributed to American origin, and so when remaining German stocks approached depletion, and the American products began to appear on the markets, these were likewise used in ways never intended, with equally as poor results as in the case of the misuse of the German dyes. With the present adequate domestic production, these matters are correctig themselves. Public sentiment can, and I believe will, make an end of the disloyal placards.

#### NEEDED LEGISLATION

Assurance of the future of the coal-tar chemical industry lies not only with our people as a whole but even more directly with their representatives in Congress, for it must not be forgotten that legislation stands to-day, as a result of the enactment of the 1916 general revenue bill, which is directly in favor of the German industry, the risk of the very life of the American industry. Every phase of the domestic industry has been studied by the Tariff Commission, and, according to a recent statement of a representative of the Commission, its report to Congress will be published soon after the passage of the revenue bill. While nothing is known of the character of this report, I am confident that when the results of this impartial study of the industry are presented to Congress the same unanimous vote will characterize the correction of errors of existing legislation as has just marked the passage by the House of the eight billion dollar revenue measure. But the time for action is short if we achieve the great military victory in 1919 to which all look forward with supreme confidence. No opportunity must be afforded for the practice of industrial infiltration which may sap the very foundations of the coal-tar chemical industry.

In this connection may I suggest the legislative correction of an error for which we chemists are primarily

responsible. In the existing act intermediates are assessed one-half the duties of finished dyes, which ratio was adopted by Congress upon our recommendation. Experience has shown that this differentiation is a mistake. The difficult stage of production is from the crudes to the intermediates, far more difficult than from the intermediates to the finished dyes. And it is in the field of intermediates that dyestuffs, high explosives and medicinals meet upon common ground. Furthermore, it is evident that when these industries bear the brunt of foreign attack the enemy will take advantage of questions of definition to avoid the higher duties, or will seek to accomplish the same purpose by shipping the lower assessed intermediates for assemblage here into finished dyes by simple processes requiring little outlay. Justification of this contention is furnished by the following extract (page 22) from the "Census of Dyes and Coal-Tar Chemicals 1917" just issued by the Tariff Commission:

With these exceptions the American dye industry was based entirely on imported intermediates. . . . This peculiar situation was due primarily to the provisions of the tariff laws of 1897, 1909, and 1913, which have consistently placed a higher duty on dyes than on intermediates. In general the German industry dominated the field and the Americans were unable to compete. It happens, however, that in the making of certain dyes the last chemical step of transforming the intermediate into the finished dye is a comparatively simple and cheap process. As the rate of duty on intermediates was lower than that on the finished dyes, the margin in some instances was sufficient to make it profitable to avoid paying the higher duty on dyes, by importing the intermediates and completing the manufacture of the dyes in the United States.

Knowing therefore where the attack will be made, would it not be the part of wisdom for us to strengthen our forces at this point by legislation which will place all of these products on the same dutiable basis?

#### COAL-TAR MEDICINALS EQUALLY IMPORTANT WITH DYES

Coal-tar dyes have received an abnormal amount of attention from our people and our press. Of equal importance and of far greater meaning to the comfort and well-being of our people are the coal-tar medicinals. In spite of unfavorable legislation our manufacturers have worthily met their responsibilities in this field. Especially is this noted in the recent statements of government officers that the needs of our Army for these materials had been fully met by our home output. Congress, I am again confident, will correct the unevenness in legislation which hangs as a life-threat over this line of production.

In spite of the lack of coöperation during the past three years some progress has been made. The 1000 tons of  $K_2O$  produced in 1915 was increased to 9720 tons in 1916 and 32,000 tons in 1917. Much fundamental investigation has been carried out, and the promise for the future is hopeful. Success can be predicted if producers and consumers get together, and if public opinion is aroused to the fact that failure to secure national independence in this matter vitally affects the entire nation. The mining bill, as modified by Senator Henderson, and now before the Senate, may prove the solution. It may be that protective duties or direct subsidy will be called for, or possibly the relief of capital invested in this industry from war

taxation. What ever the cost and whatever the method adopted, Government assistance is needed and may be secured if the demand is nation-wide. Independence in potash can be assured if this country makes up its mind that it will no longer be dependent upon Germany for its supplies, but its mind must be made up quickly. This is one of the most urgent questions, in both its economic and its political aspects, before this country to-day. We cannot afford to neglect it.

## Importance of Chemistry in Industry

BY G. W. THOMPSON

President American Institute of Chemical Engineers

THIS National Exposition of Chemical Industries, the fourth that has been held, is a growing illustration of the advantage to our industries which chemistry has afforded. The growth of our industries of all kinds has been greatly assisted by chemists. Strictly speak-



G. W. THOMPSON

ing, all industries are chemical industries, but some are more obviously chemical industries than others. This exposition has to do naturally more with the industries which are obviously chemical, but the general proposition that all industries are dependent upon chemical processes should be emphasized, even if in each case the connection is not obvious to the unthinking man.

We learn by adversity. This war has taught us that all industry is more or less chemical in its character. The fact that the assistance of chemistry has been particularly demanded during the last four years has been due to the fact that our most powerful enemy has been perhaps a little wiser than we have been in the past; and we, seeing the extent to which chemistry could be of service to a nation, both in war and in peace, have learned a lesson, although our education in this respect may not be complete. If chemistry has been of great assistance to us during this war, how much more will it be of assistance to us when the war is over and we are again in competition with a great commercial enemy that earlier learned the lesson of which



I am speaking. The few remarks that I have to make today are in the direction of trying to impress upon our people the necessity of learning this lesson more completely, learning it from day to day, learning it with respect to war and with respect to peace.

Every one needs instruction along this line, but I will address myself particularly, first, to those who control manufacturing operations; second, to the universities and colleges where chemists are taught; and third, to chemists themselves. Those who control manufacturing operations must learn more fully and completely the need of chemical knowledge for the perfection of industry, the need of chemists in their organization. Our universities and colleges must learn that however valuable pure chemistry may be as an interesting study and for the purpose of training the mind, the most important thing that chemistry does is to be found in its application; that while it is extremely interesting and upbuilding to think in terms of atoms and molecules, it is equally important to think in terms of large quantities of the chemical components that enter into reactions. Chemists must learn more fully and completely the need of applying their knowledge to chemical processes conducted on a large scale.

Permit me to elaborate my appeal for a greater education of these three groups of individuals. Again, let me speak to those who are at the head of concerns that control manufacturing operations. They will, without doubt, agree to the broad academic statement that I have already made, that all manufacturing industries are chemical to a greater or less degree and that for their successful prosecution the chemist is an essential factor. Some manufacturers are more progressive than others in this respect, and they are the ones who have made the greatest success in recent years. This academic statement, however, is to be valued by its application. Manufacturers need chemists and they should do everything in their power to secure a supply of the best chemists possible. The progress of manufacturing is dependent upon the development of chemical knowledge, and manufacturers should give their assistance in every way in their power to the development of chemical knowledge.

Manufacturers can do a great deal to help the universities and colleges in developing more efficient methods of instruction. They can do this by calling university and college professors into their councils and developing the practical sides of these professors so that the students in their charge will be developed along lines which will be useful to industry. The teacher in chemistry who is not in touch with practical manufacturing operations cannot properly instruct the student under him and build him up so as to make him capable, on graduation, of entering into the industries and applying his knowledge to their furtherance.

Practical business men often distrust college professors. They say that they are theoretical and visionary. This in many cases is due to the fact that the practical business man has a narrow vision. Sometimes it may be true that instructors in chemistry have not a practical turn of mind. Whether this view of practical business men is true or not, the remedy is in their hands, and if they will see their broad duty, they will throw open their plants more freely to instructors in chemistry and make the education of chemists a part of their

organized plan. In other words, our colleges and universities must be used by our manufacturers and our manufacturing plants must be opened to use by our universities and colleges.

Now, let me address another word to our educational institutions. They are not entirely free from criticism. It is my opinion that the educational institutions of this country should give honorary degrees to men who have accomplished big things in the industrial world. The practice in many of these institutions is to give degrees only to those who have done original work in what is called pure science but which work may be of no immediate practical use. It is my opinion that the man who discovers by hard labor things of practical value in the chemical world is deserving of some recognition from our colleges for his contribution to practical science.

I believe that our universities and colleges should, all of them, turn more to the practical aspects of education. Many of them think only of its cultural side. Culture is desirable; no one questions this, but culture is not incompatible with an education that suits a man for the practical affairs of life. It is absurd to say that a man, to be successful in the business world, must be a boor, for its corollary is that the man of culture cannot succeed in the business world. Culture with an education that will make the student of practical use is what we want, and the educational institution that thinks only of culture is about as bad off as the educational institution that thinks only of the practical affairs of life. Our educational institutions should keep in touch with manufacturing operations, and instructors in chemistry should keep their feet upon the earth, even if we cannot expect them at all times to keep their heads out of the clouds.

Since this war started it has been a wonderful thing to see how chemists generally have offered themselves to our Government in the hope that they would be able to help in solving the practical problems confronting it. Many instructors of academic chemistry descended from their exalted positions and attempted to handle problems which they, by experience, have been unfitted to solve. All honor to these men; we do not criticize them, and have only praise to offer for their self-sacrifice. How much better would it have been, however, if these men had been better acquainted with the practical matters with which they became intrusted. They came nobly to our country's assistance. They broke down the barriers with which they were surrounded, and it is a delicious hope that when peace arrives they will not allow these barriers again to be erected.

To chemists generally I address this word: You have the power of influencing the opinion of manufacturers, those that control industries and the opinions of those who control the policy of our educational institutions. I would ask you to insist upon it that the manufacturers of our country and our educational institutions get closer together and that between them there be opened up wide avenues of intercourse. The result will be that each will be modified. Our industries will be influenced by our educational institutions and our educational institutions will have breathed into them some of the life of the business world.

We all know that this exposition is to be a success, but success in the best sense of the term involves the



power of growth. Success does not consist only in the doing of single definite things, but in the bigger sense means the doing of a series of definite things, each member of the series being of a greater value than that which immediately preceded it. My few remarks are directed to the desire that chemists and chemical industries, and expositions of this kind will have the vitality and growing power so that each succeeding achievement will surpass that which preceded it, in a progressive and developing series.

## America's Supremacy in Electrochemistry

By F. J. TONE

President, American Electrochemical Society

**D**URING the past four years we all must agree that the chemical industry of America has passed through the most important period of its history. This has been a war not only between efficiently organized armies and nations but between efficiently organized in-

in spite of the strong position of the industry before the war no one would have dared to predict the expansion which the war would demand of us. It has called for chlorine, cyanamide, air nitrates and phosphorus in vast quantities. It has required the ferro-alloy industry, the electrode industry, and the abrasive industry to quadruple their outputs.

As a single example, consider briefly the contribution of electrochemistry and electrometallurgy to the aircraft program. The airplane motor has a crank case and pistons of aluminium. Its crank shaft and engine parts subject to the greatest strains are all composed of chrome alloy steel. All of these parts are brought to mechanical perfection and made interchangeable by being finished to a fraction of a thousandth of an inch by means of the modern grinding wheel made from electric furnace abrasives. Calcium carbide and its derivative, acetylene, are making possible an ample supply of cellulose acetate for airplane dope. When the aviator trains his machine gun on an enemy plane his firing is made effective by tracer bullets of magnesium or phosphorus. When our bombing planes begin to carry the war into Germany, it will be with bombs perhaps of ammonium nitrate or picric acid or other high explosives all depending largely in their manufacture on electrochemical reagents. Without the pioneer work of Hall, Acheson, Willson, Bradley and others, the present aircraft program would be absolutely impossible of achievement.

Then there is gas warfare, the very basis of which is chlorine. Germany has long been a nation of chemists and when she planned a war of frightfulness it followed as a matter of course that she should seek to make it also a war of chemical frightfulness. Much as we deplore it, therefore, we have been forced to throw our best energies to the solution of the problems of gas warfare. It is interesting to note that chlorine, the product of the electrolytic cell is the basis of mustard gas, chlor-picrin, phosgene and almost all of the important war gases. Thus does electrochemistry enter fundamentally into the modern military machine.

It is important for us to remember that while we are working to develop our industry to a point where it will meet the demands of the war, our work is only begun. If this is, in a measure, a chemists' war we must work to see that afterwards we have a chemists' peace. After the war will come bigger problems and bigger responsibilities; no one will have a bigger opportunity than the chemist to make life better and to serve his fellow man. We have the problems of the conservation and proper utilization of our resources, the elimination of wastes, the problems of foodstuffs, clothing and sanitation. All these problems and many others touch the everyday life of the people and are pre-eminently the problems of the chemist. Fortunately the nation is coming to realize to what an extent it depends in war and in peace on the work of the chemist. By the establishment of the Chemical Warfare Service, our place in the military organization has been definitely recognized. We want the same recognition in the councils of the nation after the war. We want the Government to recognize the value of scientific methods and we will look to this exposition in future years as one of the forces which will visualize to the rest of the country the role of the American chemist.



F. J. TONE

industries. Our chemical industry today is pitted against the chemical industry of Germany and one has only to study this great exposition to be convinced that the American chemist is going to measure up to his opportunity. At the beginning of the war our industry was highly organized in special fields but it lacked symmetrical development. It was unbalanced. It lacked self-containedness and coördination. It has taken the war to enable the chemical industry to find itself and it has likewise taken the war to enable this country to discover that it has a great chemical industry and to recognize it as a great national asset; and it must be said that one of the big forces which have worked toward the progress of chemistry and toward public recognition of chemistry in America has been this exposition. We give all honor to the men whose foresight and energy made this possible.

In this big forward movement of the past four years the electrochemist has played a large part. America has long enjoyed a supremacy in electrochemistry, but

# The Chemical Industry in Export Trade

**The American Manufacturer Must Study Foreign Conditions and Be Prepared to Meet the Most Exacting Requirements of Foreign Buyers. The Chemist Must Commercialize His Abilities in a Higher Degree**

By G. A. O'REILLY

Foreign Trade Representative Irving National Bank, New York

THE after-the-war foreign-trade problem to be solved by the chemical industry of this country is about the same as the big general problem which must be solved by all the other industries which hope to operate successfully in the foreign field.

The details involved in the process to be considered are well known to the experienced, and must be provided for in domestic trading as well as in that which concerns foreign fields. A market must be found, sufficient information concerning the essential conditions affecting that market must be secured, the product must be manufactured with proper reference to the requirements of the particular market, and there must be secured such a cost of production, treatment and distribution as will make it possible to meet the competition of similar products that may be coming from other sources of supply.

Some of our American industries have solved this foreign-trade problem and have mastered the essential details concerned with considerable thoroughness. Steel, oil, copper, tobacco, cotton, several machinery, equipment and appliance lines, and certain of our special lines have reached the point in foreign trade success where they are able to meet the keenest foreign competition to be met.

It will be found, too, that a large number of American general lines also have been introduced and distributed in the foreign field in a manner which contributes most effectively to our foreign trade standing, but in many such cases success accomplished has resulted not from the activity of manufacturers, nor from any intelligent appreciation on their part of the problems to be solved in foreign markets, but from the efforts of the highly developed class of institutions known as export commission houses.

From the earlier days of our experience with world markets, houses of this class have figured most importantly in the development of American foreign trade. They have studied the foreign field, have come to understand its requirements, have created organizations capable of treating the difficulties of credit, transportation and distribution and, in general, through the intelligent development of facilities, have effectively bridged the commercial chasm which under other conditions would separate the greater portion of our American product from foreign markets in which it might be absorbed to the benefit of all parties concerned.

In recent years there has been developed among even smaller American lines a disposition on the part of manufacturers to break away from export commission houses, and deal direct with the foreign customer. In many such cases, where the entire situation has been thoroughly understood results have been satisfactory but in others, where the particular manufacturer as-

sumed that there was in his situation some quality of merit which would justify him in disregarding the experience of the export commission house concerning facilities actually required, difficulty has been encountered.

If the manufacturer wishes to deal direct with his foreign customer, he will find it entirely practicable to do so, but in so doing he must realize that in each transaction there is required a more or less standard unit of facilities. In other words, if he depends upon some short cut to success, he is apt to be severely disappointed.

Of course there are among our products those whose natural popularity in world markets is so great that these markets will make almost any effort, however unreasonable, in order to get them. This condition of affairs is particularly noticeable at the present time when the demands of war must be satisfied regardless of price or convenience or anything else. It will be found, though, that even in the most conspicuous of these cases, steel, oil, etc., the necessities of the foreign purchaser have not been allowed to interfere with the development of American facilities of distribution. Indeed, in point of completeness of facilities all along the line, these major industries are among the most highly developed in existence.

## NO EASY ROAD OR SHORT-CUT TO SUCCESS

This rather extensive reference to the general aspect of American foreign trade bears upon the future of the chemical industry in world markets as showing that there is no easy or cheap way of achieving success. From the beginning, clear through to the end of each foreign trade transaction there are certain requirements which must be met, certain classes of service which must be provided. Whether they are to be provided by the manufacturer, by the jobber, by the export commission house, or otherwise, is unimportant in this discussion—the important thing is that they be provided.

The markets of the world must be surveyed and studied so that the particular product concerned will operate abroad under most favorable instead of the least favorable conditions. The wishes, tendencies, and even the peculiarities of the particular market selected must be considered as of fundamental importance. If a particular population wants a product in a certain condition or in a certain size or color, or even in a certain class of container, it is up to the American manufacturer and exporter to recognize these requirements, otherwise it will be found much better to select some other market. It will not be enough to provide a good product, even a better product than the foreign market has in mind. This is particularly true of

Oriental peoples. Like the man in the song, "They want what they want, when they want it."

#### OUR CHEMISTRY MUST BE COMMERCIALIZED

Nor is there anything in the chemical situation which will justify any disregard of these requirements upon their part. As far as the difficulties to be encountered are concerned, theirs is just a plain, ordinary foreign-trade problem, with perhaps an occasional new element of difficulty which is not encountered in other lines. It will not be enough to assume that the foreigner does not know what he wants—not enough to assume that he will be content with a leftover portion of some product which has been manufactured without any intelligent reference to his needs or wishes or whims, and above all it will be fatal to success to assume that he is under any obligation to reconcile his points of view or standards or business policies with ours. If we wish to play with him we must recognize the rules of the game as he understands them. If not, we must make up our mind to play with someone else. It is a very practical case of the old idea of "fish or cut bait."

Quite naturally, and because of certain conditions for which nobody in particular is to blame, but which are in the situation nevertheless, the chemical industry in its relations with the foreign market has more to do, more to overcome than the average American industry similarly interested. In a very considerable sense, and excepting a rapidly growing number of chemical concerns, this industry has not yet been commercialized. Certain of its products are well established in the domestic market, and in the foreign markets as well—certain of the great commercial concerns of the country have specialized in the commercial treatment of chemical products as highly as has been done in any industry, but in general, a large part of the industry still seems to be on a professional rather than a commercial basis.

#### CHEMISTS SHOULD CONTROL THE CHEMICAL INDUSTRY FROM A TO Z

When we realize the almost mysteriously professional nature of the processes which result in the creation or preparation of the chemical product, it is not difficult to see why the commercial end of the industry, as far as at least as the old school type of chemist is concerned, should be given a position of secondary importance only. But on the other hand, when we realize the ease with which in these times, and under modern methods of operation, the experimenter or discoverer becomes in turn a manufacturer, a financier, a distributor, it is not easy to understand why such a large percentage of the really high-class members of the chemical industry should be satisfied to be called in by some concern for the solution of certain of its problems, or with executing one or two of the perhaps numerous processes involved in completed commercial treatment, or with any other participation which stops short of proper control of the industry and a proper share in its profits.

This is only a layman's view of the case, and there may be perfectly good reasons why the situation is as it is, but the prodigies of accomplishment which were so clearly shown in the chemical exposition of last year in this city, leave no doubt in the mind of the layman as to the class of ability represented in that industry. It

is difficult to believe that these men who have done these impossible things should find it necessary to shy at the much simpler tasks of financing industries, or distributing their products. The chemical industry of this country in relation to foreign trade still is in its early infancy. It required a world war to puncture the bubble expressed in the theory of a necessary dependence upon Germany. What a wail went up when our American business discovered that the war had cut off our former German source of supply for dyes, and how skeptical nearly everybody was concerning the possibility of that supply being replaced from domestic sources within reasonable time—and how beautifully it all has worked out, and how easy it all seems now, and how independent we feel of Germany and all the other countries of the world, not only as regards dyes, but in at least a dozen other lines, for which before the war we had depended almost absolutely upon the intelligent enterprise of foreign lands.

#### SHARP COMPETITION WILL RETURN AFTER THE WAR

And now, after a while, the war will be over—the markets of the world will be opened, commercial monopolies such as we now know so intimately no longer will exist, or at least will be seriously disturbed; competition again will come back into the field, real competition, sharper perhaps than we have known in the past. Our world-known and commercially established chemical products probably will continue popular in the markets of the world, but this will not be enough. The lessons of the war regarding the possibilities of our own people must not be lost. Our chemical industry should claim in the markets of the world the same privilege which in the past this country so freely accorded to the chemical products of other countries.

In this process, best results in the chemical industry will be possible only when the chemist realizes that after all he and not the financier who invests, or the distributor who exports is the important element in the case. Professional he must remain, but not to the exclusion of the other impulses and qualities which the commercial world recognizes as indispensable to commercial success.

#### German Industry and the War

The *Société de Chimie Industrielle* has recently issued a special number dealing with German industry and the probable effects of the war upon it. The industrial condition of Germany before 1914 is described, and the excellent means now being adopted to better her position are pointed out, high tribute being paid to her spirit of investigation and organization. Finally, Germany's post-war aims are reviewed, and the lessons that France and all the Allies have to learn are put forward very strikingly and clearly. It is shown that Germany is concentrating all her attention upon measures for regaining her position in the world markets, and the need for reform in the training of science students in France is emphasized. Laboratory work and chemistry generally need more encouragement, and, as in England, science and industry must be brought into closer co-operation. It is an encouraging sign that the *Société de Chimie Industrielle* is rapidly increasing in membership and resources, and its efforts deserve and will no doubt attain to success in the highest degree.—*Chemical News*.



## The Slow Growth of Public Appreciation

### An Account of the First Campaign For the Chemical Independence of the United States — The First "Nitrate" Committee

By BERNARD C. HESSE, Ph. D.

THE American public has at last discovered its chemists! The importance of the chemist and of chemistry in science and every-day life seems now to be fully realized, at any rate suitably acknowledged, by the American public. That this did not take place until 1914 is in no way due to failure of the chemist to tell the public how important he and his science are, but to his inability to make the public give heed to him, as the following extracts from "Chemistry in America," by Edgar F. Smith, Provost of University of Penn., show.

On April 11, 1798, just over 120 years ago, Thomas P. Smith in closing his Annual Oration before the Chemical Society of Philadelphia, the first chemical society in the world of which any record remains, said:

"I shall now, gentlemen, conclude with a few observations on the utility of a general diffusion of chemical knowledge throughout America.

"Living as we do in a new, extensive, and unexplored country, separated by an immense ocean from all other civilized nations, we must feel ourselves deeply interested in a knowledge of *its* mineral productions, and this can only be arrived at through the medium of chemistry. As far as our very limited knowledge has yet gone, we have every reason to believe that nature has been far from bestowing her blessing upon it with a parsimonious hand. Abounding as it does with the richest ores of the most valuable metals, we should be committing a crime of the blackest dye, were we through *willful ignorance* to trample under foot these invaluable gifts of the Creator.

"The only true basis on which the INDEPENDENCE of our country can rest are AGRICULTURE and MANUFACTURES. To the promotion of these nothing tends in a higher degree than chemistry. It is this science which teaches man how to correct the bad qualities of the land he cultivates by a proper application of the various species of manure, and it is by means of a knowledge of this science that he is enabled to pursue the metals through the various forms they put on in the earth, separate them from substances which render them useless, and at length manufacture them into the various forms for use and ornament in which we see them. If such are the effects of chemistry, how much should the wish for its promotion be excited in the breast of every American! It is to a general diffusion of a knowledge of this science, next to the VIRTUE of our countrymen, that we are to look for the firm establishment of our INDEPENDENCE. And may your endeavors, GENTLEMEN, in this cause, entitle you to the gratitude of your FELLOW-CITIZENS."

During all the years since the American chemist has conscientiously lived up to the admonitions of Thomas P. Smith, he has done his appointed share. *The public alone did not respond.*

Five Philadelphia chemists on February 3, 1798 advertised "to the citizens of the United States" that in the interest of public benefit they would analyze free of all charge any minerals sent them. They did this pursuant to a resolution formed by the Chemical Society of Philadelphia certainly made arrangements for public work in the most patriotic spirit, and the record shows that they accomplished much. In 1799 the same Society appointed a committee of three (two of them among the preceding five) to get together all information as to domestic sources and modes of manufacture of niter, an indispensable ingredient of gunpowder. Here was the fore-runner of the "Nitrate Committee" recently appointed by President Wilson to determine how best to make "nitre" from the air. In 1802 the same Society offered a medal, at a cost of \$50, to the person who could produce the best specimen of clay for potters' ware in the United States.

Nor were the chemists of those days recluses; most of them were active in other professions and sciences, in politics, religion and in public affairs of many kinds. Nor were they "woman-haters" as the following, published by Smith in 1789 and earlier, show:

"I shall now present you with the last and most pleasing revolution that has occurred in chemistry. Hitherto we have beheld this science entirely in the hands of *men!* we are now about to behold *women* assert their just, though too long neglected claims, of being participators in the pleasures arising from a knowledge of chemistry. Already have Madame Dacier and Mrs. Macaulay established their right to criticism and history. Mrs. Fulhame has now laid such bold claims to chemistry that we can no longer deny the sex the privilege of participating in this science also." And again:

"Chemistry is a science particularly suited to women, suited to their talents and their situation; chemistry is not a science of parade, it affords occupation and infinite variety; it demands no bodily strength, it can be pursued in retirement; it applies immediately to useful and domestic purposes; and whilst the ingenuity of the most inventive mind may be exercised, there is no danger of inflaming the imagination; the judgment is improved, the mind is intent upon realities, the knowledge that is acquired is exact, and the pleasure of the pursuit is a sufficient reward for the labour." (Letters for Literary Ladies, before 1798).

*The American chemists of more than one hundred years ago said it all! How similar to what we have repeatedly heard as being "news" since 1914? The outlines of the picture as a whole were all supplied by them; filling in the detail was all that was left to do; the American chemist of today has done that and has always done it well. May the American public never again lose sight of its chemists!*

## Side-Lights on the Exposition

THE show, as a thing in itself, looks familiar. The Buffalo Foundry is in its old place on the main floor at the western end, the National Aniline is in its old place at the east end, south of the main entrance while the du Ponts have taken greater space than heretofore to the north of the entrance. The Norton Company is where it was and so are J. P. Devine and Co., Arthur D. Little, Inc., the General Bakelite Co.—and then comes the Barrett Co. moved over next to them. These and many other names are growing familiar even to those who visit the show to learn chemistry. The exhibits themselves on the other hand, display the greatest diversity from previous Septembers. Not only in things but in the manner of exhibiting them there has been a material change since 1914. The main purpose of the undertaking was to enable manufacturers to improve their methods and technique with materials and apparatus of which they had not been theretofore informed, and to discover how their activities might be extended; but it has gone much further than this. Exhibitors are using all kinds of devices to explain not only what they make but, as far as it is reasonable to tell, how they do it. In a first, hurried glance around the Grand Central Palace and without looking at a single exhibit thoroughly, we obtained the general impression, somehow, that the public was a great school and the exhibitors were competitive teachers. Earnest efforts are made to explain the relations of materials to each other.

\* \* \*

On the second floor, or rather the main balcony, the Chemical Warfare Service of the U. S. Army has an exhibit in charge of Major F. E. Breithut, formerly a professor at the College of the City of New York. In thirty feet of space along the corridor it displays more particularly the developments in chemical warfare, in which everyone admits the Germans were the pioneers. In many respects we have learned to view with doubt the German claims for chemical originality; to reconsider the manifold boasts to which we formerly listened with attentive and credulous ear, and to subject them to a generous discount. But poison gas and torture gas as munitions of war are products of German Kultur and if we only believed that the Kaiser is right and that he speaks the truth, we should be constrained to acknowledge that their introduction has been accomplished under Divine guidance.

Our gas warfare is carried out under the auspices of two divisions; defensive and offensive. Originals and photographs of the various allied types of masks as well as those of the enemy are shown. The new American type is also displayed and its future use in mines is clearly indicated. Offensive gas warfare is also represented by specimens of shells and grenades of many sorts.

They are designed for the various different types—sneeze, mustard lethal, phosphorous (for incendiary work and to produce white smoke) and others. An oval form of shell is shown among others that may fall into any position without becoming a dud, which is a shell that fails to explode. We may have more to say about these things later in the week.

## Program of Fourth National Exposition Chemical Industries

Grand Central Palace, New York  
Week of Sept. 23, 1918

The addresses comprise a series of symposiums devoted to a consideration of

THE DEVELOPMENT OF CHEMICAL INDUSTRIES IN THE UNITED STATES, NOTABLY SINCE JULY, 1914.

Tuesday, September 24th

Afternoon (2:30 P.M.) Symposium: ACIDS and CHEMICAL ENGINEERING.

E. J. PRANKE (American Cyanamid Co.), Development of Nitric Acid Manufacture.

EMERSON P. POSTE (Elyria Enameled Products Co.), Developments in the Manufacture of Glass Enameled Apparatus.

Evening (8 P.M.) Motion Pictures.

THE OIL INDUSTRIES

\*The Story of a Cake of Soap.

\*Light from the Rocks; Natural Gas (4 reels).

Lake Asphalt Industry (Barber Asphalt Co.).

Asphalt Roofing Industry (Barber Asphalt Co.).

Asphalt Colloids (Barber Asphalt Co.).

(9 P.M.) Speakers:

J. A. SWITZER (University of Tenn.), Waterpower Potentialities of East Tennessee.

HERBERT C. HENEGAR (American Zinc Co.), Mineral Resources of East Tennessee. (Representing Knoxville Chamber of Commerce.)

Wednesday, September 25th

Afternoon (2:30 P.M.) Symposium: POTASH.

C. A. HIGGINS (Hercules Powder Co.), Recovery of Potash from Kelp.

LINN BRADLEY (Research Corporation), Recovery of Potash from Iron Blast Furnaces and Cement Kilns by Electrical Precipitation.

JOHN W. HORNSEY, Potash from Desert Lakes and Alunite.

ALFRED DE ROPP, JR. (American Trona Co.), Potash from Searles Lake.

Evening (8 P.M.) Motion Pictures.

Electrical Precipitation of Potash from Cement Dust (Research Corporation).

\*Colloid Chemistry.

The Operation of a By-Products Coke Plant (2 reels). (H. Koppers Co.)

Moving a Forest to France (4 reels). (Southern Pine Association.)

The Story of Potash—Production at Searles Lake.

# The Economic Importance of Our Chemical Industry

The Chemical Industry Has Shown Wonderful Ability to Expand to Meet Unusual Demands Created by the War—Has Grown Much Faster Than Our General Manufacturers — United States Acquiring a Position of Independence

By FREDERICK A. CLAWSON

Economist and Statistician, The National City Company

IN 1914, the United States imported \$137,180,000 of chemicals, explosives etc., while the exports were only \$65,696,000, leaving a net excess of imports over exports of \$71,484,000. In 1916, exports were \$914,072,000, or an increase of \$848,376,000, while imports had increased only \$50,860,000, making a net increase in domestic production, due to increased exports, of \$797,516,000, or 67 per cent of the entire manufactures of 1914. In the same period petroleum production increased 9.8 per cent and coke production 57 per cent.

## EXPANSIVE POWER OF THE CHEMICAL INDUSTRY UNDER SUDDEN DEMAND

The chemical industry of the United States has shown greater efficiency and greater powers of quick response to business demands than almost any other of the great industries of the country. War requirements have made special demands upon our chemical industry, and that it has responded with great promptness and in a way evincing great possibilities of expansion is illustrated by the fact that exports of chemicals in 1917 were practically seven times as great in value as in 1914, the year immediately preceding the war, while exports as a whole were only three times as great as in 1914. Government figures of all chemicals, drugs and dyes exported from the United States were, in the fiscal year 1914, \$27,079,000; in the fiscal year 1917, \$187,846,000 and in the fiscal year 1918, \$180,000,000. Even this does not tell the full story because the great group called "explosives," in which the growth has been far more striking, is so closely allied to the chemical industry as to be in fact a part of it, and in explosives the growth is from \$6,272,000 in 1914 to \$820,000,000 in 1917, and to \$400,000,000 in 1918. While perhaps we would not class cartridges, gunpowder or dynamite as strictly "chemicals" the fact that the group which includes all of the unenumerated articles now included under the general head of "other explosives" grew from less than \$1,000,000 in 1914 to \$420,000,000 in 1917, and to \$37,000,000 in 1918, shows that in the industries closely allied with chemicals the growth has been quite as striking as in chemicals proper. In the articles which may be considered as strictly "chemicals" the growth in exports illustrates the great expansive power of this branch of our industries. Acids, for example, exported in the fiscal year 1914 amounted to less than one-half million dollars in value, in 1915 \$3,000,000, in 1916 \$24,000,000, in 1917 \$55,000,000, and in 1918 approximately \$48,500,000. Dyestuffs, of which we expected to be in very great need by reason of the cutting off of the usual source of supply from Germany, actually showed very large gains in exports, the total value of exports of dyes

and dyestuffs having grown from one-third of a million dollars in 1914 to over \$1,000,000 in 1915, more than \$5,000,000 in 1916, \$12,000,000 in 1917 and \$16,500,000 in 1918, and this exportation, it should be understood, of \$16,500,000 worth of dyes and dyestuffs in the fiscal year 1918, occurs exclusively in domestic products, and does not include any foreign dyes re-exported.

Soda salts and preparations, of which the exportation was so small in 1914 that the Government did not find it necessary to make a record, jumped to more than \$3,000,000 in the fiscal year 1915, \$12,600,000 in 1916, \$18,000,000 in 1917, and to \$22,950,000 in 1918. That mysterious group "all other chemicals" in which are included many new articles chiefly for war work, grew from \$9,000,000 value in 1914 to \$22,500,000 in 1915, \$56,000,000 in 1916, \$75,000,000 in 1917 and \$42,000,000 in 1918. These figures are cited especially to illustrate the expansive power of this, one of the most important of the manufacturing industries of the United States.

## COMPARISON WITH OTHER GREAT INDUSTRIES

The importance of the chemical industry is evidenced by comparison of the amount of capital and value of products turned out with that of other leading industries. The value of capital of the group known as "chemicals and allied industries" as shown by the census of 1915 was in 1914 \$723,000,000, and that of the group distinctly classed as "chemicals" \$224,000,000. Let us compare these two totals—\$723,000,000 for "chemicals and allied industries" and \$224,000,000 for the distinct group known as "chemicals"—with those of some of the other great industries. In the great woolen, worsted and felt goods manufacturing industry the total capital in 1914 was but \$413,000,000, or but a little more than one-half that of all chemical and allied industries. In the silk-goods industry, which turns out \$250,000,000 worth of goods per annum, the capital invested was but \$210,000,000 as against \$224,000,000 in the group strictly known as "chemicals." The total capital of the great automobile industry in 1914 was but \$408,000,000, or little more than one-half that of "chemicals and allied industries," while that of the great flouring mill industry, which turns our grains into condition for food was but \$380,000,000 or but about one-half that of "chemicals and allied industries." Even the great cotton manufacturing industry, which turns more than one-third of our enormous cotton crop into form for use shows a capital of but \$900,000,000, or a little more than that of "chemicals and allied industries."

The growth of the chemical industry is illustrated by the fact that the total capitalization of "chemicals and allied industries" as shown by the 1915 census was more than 9 times as great as in 1880, and more than 3 times



as great as in 1900, the figures of capital for "chemicals and the allied industries" having been in 1880, \$86,000,000; in 1900, \$239,000,000; and in 1915, \$723,000,000, while the value of the product turned out was in 1880, \$99,000,000; in 1900, \$263,000,000, and in 1915 \$548,000,000.

#### GROWTH OF INVESTED CAPITAL, LABOR AND VALUE OF PRODUCTS

This comparison of the growth of capital with that of value of products turned out calls attention to some extremely interesting facts with reference to the requirements of capital in this great industry, and the disposition to substitute capital for labor in production, as is the general custom in all of our industries. A comparison of the census figures of capital, number of employees and value of products turned out in the distinctly "chemical" industry (not including the group known as allied products) shows that the capital employed has increased much more rapidly than the number of men employed. The census of 1880 shows the number of employees in the distinctly chemical industry at 11,000 and in 1915, 37,782; while the capital stated in 1880 was \$29,000,000 and in 1915 \$224,000,000; thus the number of employees in 1915 was but about three and one-half times as many as in 1880, while the stated capital invested in the industry was in 1915 nearly eight times as much as in 1880; the increase in number of employees was 243 per cent and in capital 672 per cent. The value of products turned out in the strictly "chemical" industry grew from \$38,600,000 in 1880 to \$158,553,000 in 1915. In the group "chemicals and allied products," the capital grew from \$86,000,000 in 1880 to \$723,000,000 in 1915, and the product turned out from \$99,000,000 in 1880 to \$548,000,000 in 1915.

Attention is especially called to the fact that in the gradual substitution of capital for labor, in this as well, as in other industries, the amount of capital utilized in turning out a dollar's worth of material is materially greater than formerly, although the amount of labor used in turning out a dollar's worth of material is distinctly less than formerly. In the group "general chemicals" the amount of product turned out for each dollar of capital invested was in 1880 \$1.33, and in 1915 but 70c. for each dollar invested in the industry. In the great group "chemicals and allied products" the amount of products turned out for each dollar invested, as shown by the census of 1880, was \$1.15, and in 1915 74c. for each dollar invested, while as already indicated the increase in labor employed was at a far less rate than that of capital.

It is in the power of our chemical industry to rapidly enlarge its products and to quickly respond to the demands made upon it as this great industry develops, but unfortunately we are unable to closely measure the growth resulting from the demands of the war, since the latest census (that of 1915) relates to the operations of the calendar year 1914, of which only a small part was sufficiently within the area of war activities to have been materially affected in the matter of its output. The only means of measuring the growth since the census, is by the value of chemicals exported, which grew from \$27,000,000 in 1914 to \$46,000,000 in 1915, \$124,000,000 in 1916, \$187,846,000 in 1917 and approximately \$180,000,000 in 1918, this estimate for 1918, be-

ing based upon official returns for 11 months and an estimate for the closing month of the year. Meantime the importation of chemicals show only a moderate growth, though this slow growth in chemical imports since the war began is probably due in some degree to the fact that the markets of Germany, from which we brought large quantities of this class of merchandise, are no longer open to us. Chemicals imported have increased from \$83,000,000 in 1914 to \$120,000,000 in 1917, a gain of about 50 per cent in imports, while exports of chemicals increased over 500 per cent during the war period to 1917. Chemicals imported reached \$150,000,000 in 1918, a gain of about 70 per cent in imports, while exports of chemicals increase over 540 per cent.

#### UNITED STATES THE WORLD'S GREATEST EXPORTER OF CHEMICALS

A very large proportion of the chemical industry is found in the section east of the Mississippi. In New York State the group "general chemicals" in the year 1910 (the latest year for which we have figures in detail) were \$35,000,000, New Jersey \$22,000,000, Pennsylvania \$16,000,000, Michigan \$13,000,000, Ohio \$8,000,000, Massachusetts \$6,000,000 and Illinois \$5,000,000, all of these figures being in very round terms. It is not practicable to compare with any degree of accuracy the chemical industry of the United States with that of other countries by reason of the fact that the classification or groupings by the different countries of materials of this character differ so radically that the group termed "chemicals" in the official returns of one nation is liable to differ radically in the articles included from that of other countries. Prior to the war the United States was looked upon as one of the world's greatest importers of chemicals and held a comparatively low rank in the exportation of chemicals, especially when compared with certain European countries, notably Germany, France and Great Britain. Since the war the exports of chemicals of the European countries have of course greatly declined and their imports increased, and as a consequence the United States doubtless stands at the present moment as the world's greatest exporter of chemicals when measured by total value. This leadership of the United States in the world's export trade of chemicals must be considered as probably only temporary, though the enormous growth in our exports of chemicals does suggest great possibilities awaiting that industry in supplying the demands of the importing world.

Tables I, II and III show the imports into the exports from the United States of chemicals from 1910 to 1918, also the production of the group classed as "general chemicals," and of the greater group known as "chemicals and allied industries" as shown by the United States census figures for each census year from 1880 to 1915.

TABLE I—IMPORTS AND EXPORTS OF CHEMICALS INTO AND FROM THE UNITED STATES 1910 TO 1918

| Fiscal Year | Imports      | Exports      |
|-------------|--------------|--------------|
| 1910        | \$76,803,000 | \$21,416,000 |
| 1911        | 79,751,000   | 23,007,000   |
| 1912        | 77,123,000   | 25,117,000   |
| 1913        | 94,241,000   | 26,575,000   |
| 1914        | 88,039,000   | 27,079,000   |
| 1915        | 79,250,000   | 46,381,000   |
| 1916        | 109,123,000  | 124,478,000  |
| 1917        | 124,770,000  | 187,846,000  |
| 1918*       | 150,300,000  | 180,000,000  |

\*June estimated

TABLE II—PRODUCTION OF GENERAL CHEMICALS IN THE UNITED STATES AND CAPITAL EMPLOYED

| Census of | (U. S. Census Figures) |                                | Employees | Wages and Salaries |
|-----------|------------------------|--------------------------------|-----------|--------------------|
|           | Capital                | Product per Dollars of Capital |           |                    |
| 1880      | \$29,000,000           | \$38,600,000                   | \$1 33    | 11,000             |
| 1890      | 55,000,000             | 59,400,000                     | 1.08      | 17,100             |
| 1900      | 89,100,000             | 62,700,000                     | .71       | 21,200             |
| 1905      | 96,600,000             | 75,200,000                     | .77       | 22,600             |
| 1910      | 153,100,000            | 117,700,000                    | .75       | 27,600             |
| 1915      | 224,355,000            | 158,053,000                    | .70       | 37,782             |

TABLE III—PRODUCTION OF GENERAL CHEMICALS AND ALLIED PRODUCTS AND CAPITAL EMPLOYED, 1880 TO 1915

(Allied products include fertilizers, explosives, dyestuffs, essential oils, wood distillates, sulphuric and nitric acids, carbon, bone and lampblack, and paints and varnishes) \*

|      | Capital      | Product per Dollars of Capital | Value of Product per Dollar of Capital |
|------|--------------|--------------------------------|----------------------------------------|
| 1880 | \$86,000,000 | \$99,000,000                   | \$1.15                                 |
| 1890 | 180,000,000  | 125,000,000                    | .69                                    |
| 1900 | 238,500,000  | 202,500,000                    | .84                                    |
| 1905 | 324,100,000  | 281,000,000                    | .90                                    |
| 1910 | 483,700,000  | 425,100,000                    | .83                                    |
| 1915 | 722,989,000  | 547,802,000                    | .74                                    |

\* Figures not absolutely comparable because of changes in classes of articles included especially in 1890 and 1900.

Our exports of chemicals to our neighbors at the South are rapidly increasing. Exports of chemicals to South America in the fiscal year 1914 (the year immediately preceding the war) showed a total of \$3,106,000; in 1915, \$4,484,000; in 1916 \$10,886,000; and in 1917 \$15,000,000. For the fiscal year 1918 the complete figures are not yet at hand, but it is probable that they will show a total materially greater than that of 1917, and if the increase in chemicals is as rapid as that of other merchandise to South America the total for chemicals in 1918 would approximate \$20,000,000.

#### REVIVAL OF NATURAL DYESTUFF INDUSTRY

A once powerful industry, revived to something of its old proportions by the far-felt effects of the war, is the production of natural dyestuffs. Barred from accustomed supplies by the war's blockade, American color consumers clutched in desperation at any straw promising relief, and the long-dormant natural dye trade was revived. Today the United States is the largest manufacturer of natural dyes in the world, and even after peace has shrunk the present abnormal consumption, the demand for natural dyes should show a permanent increase of from 15 to 25 per cent. The future, then, of the dyestuff industry in this country seems to be full of hope and promise. If we accept our opportunity, and develop our resources with intelligence and wisdom both in legislation and in manufacturing methods, there is no reason why America and not Germany, should not be the dyestuff center of the world.

Since the war cut down England's exports of heavy chemicals there has been a perceptible shift toward New York as the center of gravity of the trade. However, the growth of production and trade in the United States has been rather to supply domestic needs than to build up an international trade. It hardly seems likely that the United States will in any way supersede England as the principal exporter of these products.

#### SULPHURIC ACID, THE BASIC HEAVY CHEMICAL

What may be called the basic heavy chemical, that from which many of the others are manufactured, is sulphuric acid, whose uses, besides the present important one of explosive manufacture, include its employment in the refining of oils and petroleum, the reclaiming of rubber, the preparation of artificial fertilizers,

the manufacture of aniline dyes, and metallurgy. It is also used in making other acids, in the Leblanc process for making soda from salt, and in bleaching.

Under normal conditions a very large proportion of the acid used in industry is manufactured on the spot. The difficulty and danger of handling it in bulk, and the relatively steady demand tend to keep it out of the open market and to minimize its importance in international trade. Germany was the chief country exporting it, shipping annually some 80,000 tons to adjacent European countries. Belgium also exported her surplus. The domestic production of each of the principal consuming countries, however, was far in excess of imports. Table IV gives the approximate production in 1913 of the countries using this acid.

TABLE IV—PRODUCTION OF SULPHURIC ACID

|               | Long Tons |
|---------------|-----------|
| United States | 3,500,000 |
| Germany       | 1,650,000 |
| Great Britain | 1,150,000 |
| Italy         | 640,000   |
| France        | 550,000   |
| Belgium       | 350,000   |
| Russia        | 260,000   |
| Sweden        | 130,000   |
| Japan         | 75,000    |
| Spain         | 16,000    |

The demands of the explosives makers and of the iron and steel industry since the war began have caused a greatly increased production in the belligerent countries, which has meant the investment of large sums in new plants. The United States in 1916 produced 5,642,000 tons, and nearly 7,000,000 tons in 1917. After the war demand ceases it is likely that the efforts of the producers to find a market will cause the acid to become a larger factor in international trade than before.

#### TRADE IN PYRITES AND SULPHUR

The production of sulphuric acid in any country is of course entirely dependent on the supply of the materials from which it is made, principally pyrites and sulphur. It is these which are transported to the point of consumption rather than the acid. The movement of pyrites in 1913 may be seen in Table V.

TABLE V—MOVEMENT OF PYRITES IN 1913

|                    | Production, Tons | Net Imports, Tons | Net Exports, Tons | Consumption, Tons |
|--------------------|------------------|-------------------|-------------------|-------------------|
| Spain and Portugal | 1,283,904        | .....             | 1,200,000         | 84,000            |
| Norway             | 441,291          | .....             | 460,912           | (Very small)      |
| United States      | 341,338          | 848,674           | .....             | 1,190,012         |
| France             | 306,267          | 186,348           | .....             | 492,615           |
| Italy              | 287,727          | .....             | .....             | .....             |
| Germany (1912)     | 258,517          | 1,070,794         | .....             | 1,329,311         |
| Canada             | 141,577          | .....             | 49,000            | 92,000            |
| Russia (1912)      | 123,990          | .....             | .....             | .....             |
| Japan              | 114,387          | .....             | .....             | .....             |
| Hungary            | 104,050          | .....             | .....             | .....             |
| Great Britain      | 11,427           | 794,740           | .....             | 806,167           |

The Spanish supply was the controlling factor in the world's market, and led the price movements. It is in the hands of a number of native mine-owners and is of the most desirable quality. The largest part of it went to Germany and Holland, with the United States next as buyer. Great Britain and France also took large quantities. The Norwegian pyrites went chiefly to Germany. The war, although greatly stimulating the demand for pyrites, at the same time has cut off from the rest of the world one of the largest purchasers—Germany. The scarcity of ships and the high freights on such a bulky material have tended to encourage consuming countries to develop their own supplies rather than to depend on imports. Germany has undoubtedly been hard put to it to replace the loss of the Spanish

supply. Great Britain, being practically without domestic supplies, has imported Spanish pyrites in increased quantity. Her total imports in 1916 were 951,206 tons. The United States similarly took larger quantities of the Spanish ore, 854,432 tons in 1914, 747,027 in 1915, and 1,117,968 in 1916. Early in 1917 however, owing largely to the German submarine warfare, the shipments to this country of Spanish pyrites stopped, and have only recently been resumed. The domestic production in the United States had been steadily growing through the opening of new mines.

The world's trade in sulphur, which normally is used chiefly in the manufacture of paper pulp, has been shifted. It forms a larger item of trade than the manufactured pulp, and is mined in comparatively few places. Table VI gives the total movement of sulphur in 1913.

TABLE VI—MOVEMENT OF SULPHUR IN 1913

|                  | Production,<br>Tons | Net Imports,<br>Tons | Net Exports,<br>Tons | Consumption,<br>Tons |
|------------------|---------------------|----------------------|----------------------|----------------------|
| Italy and Sicily | 413,727             |                      | 414,717              | (Small)              |
| United States    | 311,640             |                      | 67,101               | 244,539              |
| Japan            | 65,467              |                      | 11,650               | 53,817               |
| Spain            | 62,653              |                      |                      |                      |
| New Zealand      | 12,000              |                      |                      |                      |
| Austria          | 10,564              |                      |                      |                      |
| Chile            | 4,400               | 38,142               |                      | 48,703               |
| Canada           |                     | 32,984               |                      | 4,400                |
| Germany          | 1,251               | 43,265               |                      | 32,984               |
| Great Britain    |                     | 18,519               |                      | 44,516               |
| Sweden           |                     | 39,715               |                      | 18,518               |
|                  |                     |                      |                      | 39,715               |

#### GERMANY DOMINATED WORLD MARKET FOR BLEACHING MATERIALS

Another group of heavy chemicals upon which the war has had a considerable effect is that of the various bleaching materials, which are all-important to the textile trade. The world's production of bleaching powder is estimated at 500,000 tons a year. It was obtained chiefly from England and Germany. England, besides producing very large quantities for her own industries, exported in 1913 some 36,319 tons of the material, of which 27,362 came to the United States. England also supplied the distant markets such as India, China, South America, and numerous other countries. In most of the world market, however, especially in Europe, the German product had attained a dominating position. The growth of the electrolytic manufacture of caustic potash from the abundant potash deposits of Stassfurt, in which chlorine is a by-product, had made possible the production of bleaches at a very low cost, in a quantity far in excess of home requirements. The exports in 1912 were 32,254 tons, of which the United States as principal buyer took 9574 tons. France also manufactured a small exportable surplus, in addition to supplying her own extensive textile industries. Bleaching powder was not made commercially outside of Europe until the opening of the electrolytic works at Niagara Falls in 1900. Since then the American output has increased rapidly, although not keeping pace with consumption. The United States consumption in 1913 was about 57,600 tons, of which the domestic production supplied only 19,600 tons.

The war of course completely removed German bleaches from the market, and also cut down British exports considerably, owing to domestic scarcity. In their place American and Japanese bleaching powders have appeared. The electrolysis of common salt in the United States has been largely instrumental in increasing the supply. Demands poured in from foreign buyers, and the United States has become an important exporter of this product.

#### UNITED STATES WILL BE SELF-SUPPORTING IN BLEACHING MATERIALS

The return of peace will find the United States, formerly the principal buyer of bleaches, quite self-supporting. It is a question, however, whether the American product will be able to compete abroad with the cheap British and German product.

The consumption of bleaching powder during the past few years has been affected by the extended use of liquid chlorine which was formerly produced only in Europe, chiefly in Germany, but which is now manufactured here in large quantities and finds an extensive use in reclaiming scrap metal as well as in bleaching. Sodium peroxide, also much in demand as a bleach, is now made at Niagara Falls, replacing the European imports. Caustic soda, which is produced at the same time with chlorine in certain processes and is used in any number of industries—soap making, the manufacture of paper pulp, the mercerizing of cotton, the purification of mineral oils etc.—was obtained from England before the war chiefly. Germany specialized more in caustic potash and did not compete directly. The war has cut down British exports from 75,000 tons to a very small figure, and as in other lines the United States and Japan have partly taken the place. The impossibility of obtaining soda in the usual markets has caused a foreign demand here that has taken up all that the producers could spare.

A similar situation exists in the case of the carbonates and soda ash. England is normally the chief factor in the world markets, exporting some 200,000 tons a year. British exports have kept up well since the war began, but nevertheless the United States has found it profitable to export these products where they were imported before the war.

In the cyanides, essential to metallurgy, and the chromates and sulphates (saltcake), Germany formerly controlled the market, England being second. The United States was a large buyer of cyanide, but recently the Niagara Falls works have produced large quantities.

#### DISLOCATION IN FERTILIZER MOVEMENTS

In the field of fertilizers, in which the largest international movements of chemicals took place before the war, the dislocation has been large. Potash, over 90 per cent of which is used for fertilizers, has been most affected, as Germany is practically the sole source. The Stassfurt mines, operated by German capital, are united in a close cartel or monopoly of which the German government is a member, which fixes the output, handles all sales throughout the world, divides it into portions for domestic use and export, and fixes wholesale prices. Owing to the complete monopoly, prices have always been entirely artificial and yielded large profits.

The United States was by far the largest consumer outside of Germany herself. The efforts to produce potash here from Western alkali lakes, alunite, and Pacific kelp, although aided by government appropriation and stimulated by the high prices since the cessation of imports from Germany, have had small results compared to the normal consumption. Foreign sources, such as those near Barcelona, Spain, have not been more successful. The German mines, on the other hand, although cut off from most of their outside markets,



have been kept running by war demands at home, producing 904,000 tons in 1914; in 1915, 680,000 tons; and in 1916, 714,000 tons. In view of the fact that prices could be considerably lowered from their pre-war level without jeopardizing profits, there seems so far little likelihood that the German monopoly will be less secure when peace is signed. The substitutes that have been developed, however, will undoubtedly affect consumption in industries other than the fertilizer. Potash salts are used to a great extent in making soap, fireworks and glass. The substitution of soda compounds for potash in making glass, which has been very successfully carried out, will come near making the world independent of German glass. A similar substitution is proving a success in soap making. Potash explosives are not made now to any great extent outside of Germany.

#### NITRATES, NATURAL AND ARTIFICIAL

The recent action by the Government of the United States for the establishment of works for the production by artificial process of the nitrates for which the United States has been heretofore dependent upon the supplies imported from the great nitrate beds of Chile, calls attention to the wonderful development, especially since the beginning of the war, in the art of obtaining nitrate from the air.

In the five years preceding the war Germany imported an annual average of 700,000 tons of nitrate of soda from Chile, France about 350,000, Belgium for herself and neighbors about 350,000, Great Britain 150,000, the remainder of Europe about 300,000 tons, and the United States about 500,000. While some of this was used for the production of explosives, especially by Germany and France, and also limited quantities for the production of nitric acid for chemical industries, a very large proportion was used in times of peace as soil food.

Practically all of the nitrate supplies of the world have in the past come from Chile, whose exportations have in recent years averaged about 2,400,000 tons per annum, and the importations of Europe and the United States have as above noted aggregated about 2,300,000 tons per annum in the five years preceding the war. With the opening of the war all of the great importers of nitrates, Germany, France, the United Kingdom and the United States, realized the importance of greatly increasing their nitrate supplies for use in manufacturing war material as well as a continuation of its use for soil food.

The quantity of nitric acid required by the United States Government for its own uses in the manufacture of explosives is estimated at 20,000 tons per annum in times of peace, and in time of war 180,000 tons, while that of the other countries may be measured by the fact that Germany has increased the product of the nitric acid-producing materials to an equivalent of 100,000 short tons in 1915 and 320,000 in 1917.

#### SUMMARY OF PROGRESS SINCE 1914

In summarizing the progress in the chemical industries since 1914 it is interesting to note that we are exporting dyes and chemicals to Germany's old clients. For instance in 1917 we sent Spain \$3,192,000 worth of dyes, as against a total which was not important

enough to enumerate in Government statistics in 1914. France took \$1,404,576 worth against \$49,000 in 1915 and less than that in 1914. Mexico took \$576,000 worth in 1917 against \$2,000 worth in 1915, Argentina \$423,000 against \$32,000, and Brazil \$1,395,000 compared with \$11,000. British India imported from us \$1,237,000 worth compared with \$11,000 in 1915.

Before the war 90 per cent of the artificial dyes and colors were imported, five or six concerns with 400 operatives producing 3300 short tons per year. Now there are over 100 enterprises, each making special colors and over 100 concerns making crudes and intermediates. Sulphuric acid has doubled in production. In 1916, 6,250,000 tons of 50 degree Baumé were produced. The estimate for 1917 is much greater and the production for 1918 will again greatly increase. Gasoline production has increased from 35,000,000 to 70,000,000 barrels per annum since 1914. The production of explosives and consequent consumption of nitric acid has increased enormously. The smelting of all metals, iron, zinc, copper, antimony, tin, mercury etc., and the production of their alloys, has increased to meet the country's needs. Potash importation from Germany was stopped by the war and its production in this country in 1917 was over 28,000 short tons. By-product coking doubled its capacity in the last three years. Light oil, which contains the benzene and toluene needed for explosives, jumped from 7,500,000 gallons in 1914 to 60,000,000 gallons in 1917 and is again being largely increased. Ammonia production has increased 100 per cent in three years and the visible supply is insufficient to meet the demands. From these facts it is easy to realize that the growth of the chemical industries in the United States since 1914 has been phenomenal. Not only have factories sprung up to manufacture products formerly imported, but great expansion has taken place to supply the increased demand for all chemical products. The country now manufactures practically everything required along chemical lines. These are but a few instances of our chemical progress, but they show that we can go forward with every confidence of no serious shortage of the many chemical products required for domestic consumption or foreign export.

#### Five-Hundred-Ton Government Powder Plant at Nashville

This plant is being built in nine units—each one complete in itself. One of these units is approximately eight times the size of the largest smokeless powder plant in the United States prior to 1914. The entire plant is 70 times as large as the largest plant before the war. It covers an area one and one-half miles wide by three miles long. To operate it at capacity will require 1,500,000 pounds of nitrate of soda per day—675,000 pounds of sulphur per day. It will consume 4500 tons of coal for each 24 hours, which is equivalent to 100 carloads, or two trainloads. It will require 100,000,000 gallons of water per 24 hours, or as much water as is used by a city having a population of one million people. The central power plant will contain 68 boilers, each with a rating of 825 horsepower. It will be the largest smokeless powder plant in the world and the last word in powder making. It will require 20 to 25 thousand men ten to twelve months to complete it.

# Statistics of Chemical Imports in Preparation

The American Chemical Society Adopts Comprehensive Plan to Give the Chemical Industry Vital Information Regarding This Country's Chemical Dependence

THE Council of the American Chemical Society took no more important action at the recent Cleveland meeting than its adoption of the report of the committee cooperating with the Bureau of Foreign & Domestic Commerce in obtaining statistics on chemical imports for the fiscal year 1913-1914. The recommendations of the committee call for the appointment of a permanent Committee on Import Statistics, comprising the editor of the *Journal of Industrial & Engineering Chemistry* and the vice-president of the American Chemical Society. The plan of action will result in giving us for the first time an intelligent comprehension of our chemical dependence as well as a basis for building wisely in the future.

A great deal has been said in general terms during the past few years about our chemical dependence on foreign countries, particularly Germany. To a certain extent this has been true, although it is possible that the real facts have been exaggerated. In any event there was but one way to ascertain the real extent of our dependence, and that was to analyze the invoices of imported chemicals, raw or finished, in the Bureau of Foreign & Domestic Commerce, and list the items therein contained. In this way alone would it be possible to arrive at information which was essential to any intelligent efforts to build up the chemical industry in this country.

Largely through the efforts of Dr. B. C. Hesse, who has been the leading spirit in this matter for the American Chemical Society, and the cooperation of Dr. E. R. Pickrell of the U. S. Appraisers' Stores of the Port of New York, the laborious task of reviewing the invoices of the Bureau of Foreign & Domestic Commerce has been under way for some time past and promises to be completed by December 1, 1918. An idea of the extent of the work involved can be gained from the fact that upward of 20,000 invoices of imported chemicals has to be segregated from a total of more than 500,000 general invoices from all ports of entry. From these 20,000 invoices it was then necessary to transcribe the individual items, which will amount to more than 4000.

The information which will be gained regarding these 4000 items will comprise:

1. The name of the chemical, or material for the chemical industry.
2. The total quantity imported, expressed in pounds or other units.
3. The total value, expressed in dollars.
4. The countries of origin, arranged in the order of their participation, and showing the percentage of such participation.

It is expected that this information will fill a book of about 300 pages, which will be issued about February 1, 1919, and sold to the public at 30 cents per copy. Here, then, we will have the true story of our chemical dependence in 1913-1914, the last normal year before

the war. We will know what we imported, and how much; what it was worth and where it came from. With these facts at hand we should be able to determine the possibility of independence and whether it is worth striving for. In some items the game may not be worth the candle, or we may not have the requisite raw materials in this country. In such an event our manufacturers will be well advised to dismiss any thought of engaging in their production.

## COÖPERATION OF GOVERNMENTAL AGENCIES

But in the conception of Dr. Hesse's committee it will not do to stop with this information, for still more important and valuable data are to be obtained by elucidating these statistics. He recommends that the American Chemical Society classify the 4000 or more items of import into groups showing their mineral, animal or vegetable origin. Having done this he would seek the cooperation of governmental agencies in ascertaining foreign and domestic resources of these materials. It requires no stretch of the imagination to discern the far-reaching influence of such a plan. The Geological Survey, for example could prepare a concise statement of the world's resources of the items of mineral origin. This would show whether or not we have a domestic source of supply of a given material that would support local manufacture in case someone undertook it. It would show our resources and deficiencies, and suggest to the Survey the most profitable lines of search for minerals. Similarly the Department of Agriculture would cooperate on the items of animal and vegetable origin. There would remain then, to complete our economic knowledge of these 4000 items of import, only a statement of the industrial and commercial uses of the materials. And we understand that the Tariff Commission has been approached on this score, with the prospect of securing the desired cooperation.

## A PERMANENT COMMITTEE CHARGED WITH RESPONSIBILITY

When the foregoing is an accomplished fact we will know the extent of our dependence on foreign countries. When that is known it will be time to compile similar statistics and data on our chemical exports and our domestic production. The achievement of these ends will leave little to be desired for the intelligent direction of our chemical industry. But in order to accomplish the purpose it is necessary that some permanent body be charged with responsibility for the results and vested with the requisite authority to produce them. Hence the committee's recommendation that two officials of the American Chemical Society be charged with this duty. The committee is properly small—two, with power to add to their number and invite cooperation from other societies. The service to the industry is worthy of the American Chemical Society, and we look to see an early and satisfactory performance of duty.

## War Disturbances and Peace Readjustments in the Chemical Industries\*

A Bird's-Eye View of the Dislocations of Normal Trade and Industry Caused by the War—Expansion for War Needs—New Uses Must be Discovered for Chemicals Now Devoted to War Purposes

By GRINNELL JONES

Chemist to the United States Tariff Commission

WHEN peace is restored the competitive strength of the nations in all industries will have been profoundly altered. Chemistry and machinery have played a larger part in this war than in any previous war, and therefore the greatest changes may be expected in the metal working and in the chemical industries. Moreover, our new American cargo ships will make us more than ever interested in foreign trade. The Tariff Commission is actively studying these war disturbances in order to assist in the readjustment and reconstruction that must follow when peace comes.

Among the chemical industries, the first to feel the stimulus of war was the explosive industry. The expansion of American smokeless powder plants was sufficient to prevent a German victory in France and Russia in 1915. It is not revealing military secrets to say that there has been some growth since 1915. We all hope that the peace terms will be so satisfactory that the military explosive plants themselves will no longer be needed. Nevertheless, there will be a permanent increase in the competitive strength of the American chemical industries through the growth of the subsidiary industries which now supply the raw materials to the explosive industry.

### SULPHURIC ACID PRODUCTION DOUBLED

Our production of sulphuric acid is at least twice what it was before the war. The growth has been largely in contact acid, and therefore when the demand for explosives disappears, the American chemical industries will have available large supplies of pure and concentrated sulphuric acid. Moreover, the growth of the acid industry has been made possible by a great increase in the production of American sulphur and by a smaller although significant increase in the mining of pyrites.

The nitric acid industry has grown relatively more than the sulphuric acid industry. The output of nitric acid from Chilean niter is now more than ten times as great as it was before the war.

The significance of this growth of the sulphuric and the nitric acid industries to our dynamite, dyestuff, and pyroxylin plastic industries need not be emphasized here.

### SYNTHETIC AMMONIA AND NITRIC ACID

Of greater significance than this stimulus to industries already well established has been the birth of new industries. We have a new synthetic ammonia and nitric acid industry. Plants have been built and, during the war at least, will be operated by the Government.

When the full story of these plants can be told, it will reveal that American chemists have, under the pressure of war needs, been able to devise substantial improvements upon the Haber and Ostwald processes developed by the Germans before the war. These processes were the result of nearly two decades of work on these problems as a part of their military preparedness. It is not improbable that after the war nitric acid made from synthetic ammonia may prove to be cheaper than nitric acid made from Chilean niter. In any case American agriculture will assuredly have a new large source of nitrogeous fertilizer materials.

### LARGE SUPPLIES OF BENZOL AND TOLUOL AFTER THE WAR

In 1914 our production of crude light oil would have been sufficient for the production of only about 4,500,000 gallons of benzol and of about 1,500,000 gallons of toluol, and only a part of which was distilled. As is shown in our forthcoming report on the production of American dyes and coal tar chemicals, in 1917 our output of benzol was 40,200,000 gallons, and of toluol was 10,200,000 gallons. In 1918 further substantial growth is to be expected through the installation of stripping plants at city gas works. The toluol is now going almost entirely into explosives as is also a considerable fraction of the benzol. When the demand for explosives disappears, it is to be expected that the prices of benzol and toluol will drop to the point where it will be profitable to add them to gasoline for motor fuel. A similar condition will probably exist abroad and, since America has the greatest known natural resources for the production of gasoline, benzol and toluol should be as cheap or cheaper here than abroad. Therefore the industries consuming benzol and toluol may be assured of ample supplies of these materials at favorable prices.

### SYNTHETIC PHENOL AND MONOCHLOROBENZOL ARE WAR BABIES

Before the war we had no synthetic phenol industry, whereas in 1917, as is shown in our forthcoming report, 15 plants produced 64,146,499 pounds of phenol valued at \$23,715,805, most of which was used in making picric acid. If this new industry is to survive, there must be a greater consumption of phenol in the industries for peaceful purposes. Fortunately, phenol is used as an intermediate in the manufacture of some representatives of every class of finished coal-tar chemical products including dyes and lakes, photographic developers, medicinals, flavors, perfume materials, synthetic resins, synthetic tanning materials and explosives. Leaders in the chemical industries are already making plans for

\*An address delivered at the meeting of the American Chemical Society in Cleveland, September 10.



the industrial development of the uses of phenol when the phenol is no longer needed for explosives.

Another war baby is monochlorobenzol, which was made during 1917 by eight American firms, with an output of nearly twenty-five million pounds, valued at a little less than five million dollars. The dye industry will use a part of this productive capacity permanently, but new discoveries by American chemists will probably be needed to utilize the total productive capacity. Incidentally, this product furnishes a new outlet for chlorine, a new by-product source of muriatic acid and raises a new problem in the utilization of dichlorobenzol, an unavoidable byproduct.

Before the war there was but one producer of aniline oil in the United States. In 1917 there were twenty-three producers with an output of 28,806,524 pounds, valued at \$6,758,535. As only a relatively small proportion of this substance goes into explosives, the peace readjustments will not be complicated by a collapse of a military demand, but will depend primarily on the competitive strength of the American industry.

The war has also stimulated the production of mercury for the manufacture of fulminates. The American production has about doubled since the beginning of the war. Formerly we had a balance of imports; now we have a larger balance of exports.

#### INFLUENCE OF GAS WARFARE ON CHEMICAL INDUSTRY

Poison-gas warfare is also destined to have a permanent influence in the chemical industries. Although there is no reason to expect that uses will be found for phosgene and mustard gas on a scale approaching the present and prospective military use, the plants erected for their manufacture need not prove a total loss when the military demand ceases. Nearly all of the noxious substances used in poison-gas warfare require chlorine for their manufacture, and an increase in the production of chlorine in the United States is therefore certain. There is much hope that some of the substances produced as intermediate steps in the manufacture of the poison gases may be utilized for purposes other than warfare, but these are matters not yet to be discussed. Phosgene, except for the dangers attending its use, is an excellent reagent for many processes involving chlorination or dehydration and for making Niehler's ketone. Fortunately, the risk in using phosgene is greatly minimized by the development of the new gas mask. The intensive work which hundreds of American chemists have been and are doing to improve the design of the gas mask will undoubtedly prove a blessing to workmen exposed to noxious fumes in chemical factories throughout the world when peace is restored.

#### ACETONE, ACETIC ACID AND BUTYL ALCOHOL

Still another industry which has been stimulated by a direct war demand, is the manufacture of acetone, which is used as a gelatinizing agent in the manufacture of the explosive, cordite; as a solvent for airplane dopes; and in the manufacture of poison gases. Before the war, acetone was obtained entirely as one of the products of the wood distillation industry, but there are now at least four new processes in commercial operation in the United States or Canada for the manufacture of acetone.

It has been found that glucose can be fermented by

a suitable organism to give acetone directly. Butyl alcohol is a byproduct of this fermentation, and becomes commercially available in appreciable amounts. The development of uses for butyl alcohol is an attractive problem.

The other processes for making acetone produce acetic acid or an acetate as an intermediate step, and may therefore permanently affect the acetic acid industry. The most obvious and perhaps the simplest of these processes depends on fermenting molasses to alcohol, which is then converted into acetic acid by the rapid vinegar process. The conversion of acetic acid into acetone in an old and well known process, but the details have been improved.

Another process depends on making acetylene from calcium carbide. By the aid of a suitable catalyst, the acetylene is made to combine with water yielding acetaldehyde which may be readily oxidized to acetic acid. Still another process depends on fermenting ~~acetone~~ under such conditions that sodium acetate and potassium salts are secured.

The war has stimulated the production of many other products, a few of which may be briefly mentioned: castor oil for lubricating airplane motors; phosphorus for incendiary bombs; barium and strontium nitrates for signal rockets. The output of soda ash has increased by 68 per cent since 1914, and the output of caustic soda has more than doubled.

#### CURTAILMENT OF IMPORTS AFFECTS DYE INDUSTRY

New conditions in the chemical industries have also been created by the curtailment of imports. As a direct consequence of this stoppage of imports from Germany a new American dye industry has been established. It is true that some dyes were being made in the United States before the war, but the makers relied on Germany for the necessary intermediates, with the exception of a small amount of aniline made here by a single producer. During 1917, 134 different intermediates were made by 118 firms. One firm made 53 different intermediates. Dyes were made by 81 firms. The total production of dyes in the United States during 1917 was approximately equal in gross weight to the annual importations before the war. The exports of American dyes exceeded in value, although not in quantity or variety, our imports before the war. The dye industry is not dependent on any imported raw material except sodium nitrate from Chile. Many important dyes are still lacking, but indigo and alizarin are now on the market in significant amounts, and the vat dyes for cotton derived from anthracene are coming.

A new potash industry has also arisen, but its future does not seem so promising as the future of the new dye industry. Here Germany has an inherent geological and geographical advantage. Although shipments from Germany ceased early in 1915 and although prices have advanced to about ten times the pre-war prices, the American production during 1917 was only about 13 per cent of our pre-war consumption. This relatively small production was obtained from many sources and by many processes. There is an excellent prospect that the recovery of potash as a byproduct of cement mills will survive German competition and ultimately supply about one-third of our needs. In addition, significant amounts will probably be secured as a byproduct of the pig-iron

blast furnace. That the other branches of the potash industry can survive German competition is open to serious question.

#### UTILIZING SHIPPING CAPACITY TO BEST ADVANTAGE

Within a few months after the outbreak of the war, imports to the United States from Germany and her allies came to an end. As the months went by, it became increasingly difficult to obtain cargo space for imports from any part of the world. Now the limiting factor in the American participation in the war is shipping for our troops and their supplies, and therefore ships are no longer free to seek the most profitable cargo and route, but are being assigned to routes and cargoes by the Shipping Board on the basis of military needs rather than profits. The Shipping Board has organized a Division of Planning and Statistics, which is making a study of world commerce and the military and civil requirements, for the purpose of utilizing available shipping in a way that will contribute most to the winning of the war. Military requirements make it essential that an abnormally large proportion of the world's shipping shall be used in the North Atlantic. This has made it necessary to curtail imports from other parts of the world to essential requirements.

W. B. D. Penniman of Baltimore is the chemist on the Staff of the Shipping Board. He must decide what chemicals need not be imported at all, and the amounts of others which must be imported to supply essential needs. The importance of this work can perhaps best be made clear by an example. The Shipping Board, after consultation with the Food Administration, decided that ships could not be spared for the importation of tapioca from Java and the Straits Settlements. The War Trade Board accordingly announced that licenses for the importation of tapioca would not be granted. Efforts were immediately made to secure a modification of this order on behalf of manufacturers of nitro-starch for the Army, and on behalf of manufacturers of mucilage for the Post Office Department. Nitro-starch which, in the United States at least, was hardly beyond the experimental stage at the outbreak of the war, has been improved until it is now one of the safest of all explosives to handle and finds important military uses. Until a few months ago it was made from tapioca. Penniman, however, succeeded in convincing the officers of the War Department and the manufacturers that a satisfactory product could be made from corn-starch.

The details of the manufacture have been worked out cooperatively by the starch producers, the manufacturers of nitro-starch and the experts of the War Department with such success that nitro-starch from corn is not only better but more economically produced than nitro-starch from tapioca. The Post Office Department also readily agreed to use some locally available material instead of tapioca for mucilage on stamps. The shipping saved on this one item of tapioca for nitro-starch is sufficient to transport and sustain in France more than twenty-five thousand fighting men. Mr. Penniman's services to the nation on questions of this character deserves to be better known and appreciated. Imported materials for the time being should be used with the utmost economy and only for essential needs. American chemists can render valuable public service by find-

ing substitutes for materials which must be imported from overseas.

It seems probable that many of the discoveries in regard to the use of substitutes for imported materials made under this pressure of war needs will prove of permanent value and have a permanent influence on international trade.

#### DISLOCATIONS IN THE FERTILIZER INDUSTRY

A third source of war disturbances in the chemical industry has been due to the diversion of materials from their customary use to war uses. The fertilizer industry has probably made the greatest sacrifices of this sort. Sodium nitrate and ammonia are required for the manufacture of explosives in such large quantities that the amount left for use in fertilizers has been and will be much reduced. Raw phosphate rock has of course been plentiful but the acid used in the manufacture of acid phosphate has been largely diverted to making explosives. The relatively small supplies of potash have been very high in price and normal amounts have not been available at any price. The peace readjustments may however be expected to bring compensation to the fertilizer industry. Large new supplies of nitrogenous fertilizer materials will be available from the new nitrogen fixation plants. The new and enlarged sulphuric acid plants must again find the chief outlet for their product in the making of fertilizers. Finally, the German monopoly of the potash market is likely to be broken through the French control of Alsace and the new developments in America and Spain when peace comes. It is therefore reasonable to expect a large increase in the manufacture and use of fertilizers with a resulting benefit to all producers and consumers of food.

Chlorine also is likely to be diverted from its normal uses to the manufacture of poisonous gases to a considerable extent. In spite of the erection of new plants it is quite probable that we may all be asked to use paper lacking in the whiteness to which we have been accustomed.

Chemists in industries using chlorine should prepare to facilitate this diversion now, and plan to use more chlorine later when the military demand ceases.

It is evident that the *status quo ante* cannot be re-established in the chemical industries any more than it can be re-established in international relations. Peace will bring new conditions of international competition and radical readjustments in industry from a war basis to a peace basis.

The Tariff Commission is endeavoring to secure and have ready for immediate use all information likely to be helpful to Congress in determining the part which the tariff is to play in these readjustments. We desire information in regard to the industrial development and technical progress of industries throughout the world; in regard to the sources of their raw materials and the uses of their products, and in regard to any changes in conditions likely to have a permanent influence on costs of production, or the competitive strength of industries here and abroad. The assistance and coöperation of manufacturers, importers and consumers in the collection and interpretation of the information mentioned is desired.

Washington, D. C.

| TABLE A.—GROWTH OF AMERICAN CHEMICAL INDUSTRIES 1909 TO 1914 |                                                                                                                                                                                        |                  |                              |               |                                  |                              |                                                        |      |                                                                              |
|--------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------|------------------------------|---------------|----------------------------------|------------------------------|--------------------------------------------------------|------|------------------------------------------------------------------------------|
| Item                                                         | All Industries                                                                                                                                                                         |                  | Chemical and Allied Products |               | Per Cent Increase 1914 Over 1909 |                              | Per Cent of the Whole in Chemicals and Allied Products |      | Per Cent Increase in 1914 Over 1909 of Whole in Chemical and Allied Products |
|                                                              | 1909                                                                                                                                                                                   | 1914             | 1909                         | 1914          | All Industries                   | Chemical and Allied Products | 1909                                                   | 1914 | 1909                                                                         |
| No. of establishments.....                                   | 268,491                                                                                                                                                                                | 275,191          | 2,140                        | 2,461         | 3                                | 15                           | 0.79                                                   | 0.89 | 13                                                                           |
| No. of wage earners (av.).....                               | 6,615,046                                                                                                                                                                              | 7,036,337        | 70,426                       | 86,788        | 6                                | 23                           | 1.06                                                   | 1.23 | 16                                                                           |
| Capital.....                                                 | \$18,428,269,706                                                                                                                                                                       | \$22,790,970,937 | \$483,729,410                | \$722,989,000 | 24                               | 49                           | 2.62                                                   | 3.17 | 21                                                                           |
| Value Added by manufacture (Item 6 less Item 5).....         | 8,530,261,000                                                                                                                                                                          | 9,878,145,873    | 166,968,565                  | 206,864,000   | 16                               | 24                           | 1.96                                                   | 2.10 | 7                                                                            |
| Column.....                                                  | A                                                                                                                                                                                      | B                | C                            | D             | E                                | F                            | G                                                      | H    | I                                                                            |
| NOTE.—Percentages given above were obtained as follows:—     | $E = \frac{(B - A) \times 100}{A} \quad F = \frac{(D - C) \times 100}{C} \quad G = \frac{F - E}{E} \times 100 \quad H = \frac{D \times 100}{B} \quad J = \frac{(H - G) \times 100}{G}$ |                  |                              |               |                                  |                              |                                                        |      |                                                                              |



TABLE 5

## INDUSTRIES WITH GROSS VALUE OF PRODUCTS OF \$100,000,000 OR MORE IN 1914

| Industry                                                                             | Wage Earners<br>(Average<br>Number) |               |               | Cost of<br>Materials |               |               | Value of<br>Products |               |               | Value Added by<br>Manufacture |               |               |
|--------------------------------------------------------------------------------------|-------------------------------------|---------------|---------------|----------------------|---------------|---------------|----------------------|---------------|---------------|-------------------------------|---------------|---------------|
|                                                                                      | Rank,<br>1914                       | 1909-<br>1914 | 1904-<br>1909 | Rank,<br>1914        | 1909-<br>1914 | 1904-<br>1909 | Rank,<br>1914        | 1909-<br>1914 | 1904-<br>1909 | Rank,<br>1914                 | 1909-<br>1914 | 1904-<br>1909 |
| All industries                                                                       |                                     | 6.4           | 21.0          |                      | 18.3          | 42.9          |                      | 17.3          | 39.7          |                               | 15.8          | 35.5          |
| <i>Industries with products valued at \$500,000,000 or over</i>                      |                                     |               |               |                      |               |               |                      |               |               |                               |               |               |
| Slaughtering and meat packing                                                        | 19                                  | 12.5          | 18.5          | 1                    | 21.0          | 47.8          | 1                    | 21.9          | 48.3          | 13                            | 28.2          | 51.9          |
| Iron and steel, steel works and rolling mills                                        | 5                                   | 3.6           | 15.7          | 3                    | 10.1          | 49.0          | 2                    | 6.8           | 46.3          | 4                             | -0.1          | 41.0          |
| Flour-mill and gristmill products                                                    | 42                                  | 0.7           | 0.7           | 2                    | -2.0          | 23.8          | 3                    | -0.7          | 23.9          | 21                            | 8.1           | 24.7          |
| Foundry and machine-shop products                                                    | 3                                   |               |               | 6                    |               |               | 5                    |               |               | 1                             |               |               |
| Lumber and timber products                                                           | 1                                   | -12.3         | 35.3          | 11                   | 6.2           | 44.6          | 4                    | -5.1          | 29.9          | 2                             | -11.2         | 23.2          |
| Cotton goods                                                                         | 2                                   | 2.2           | 19.6          | 4                    | 18.6          | 29.1          | 6                    | 10.0          | 39.0          | 7                             | -2.5          | 16.6          |
| Cars and general shop construction and repairs by steam-railroad companies           | 4                                   | 20.3          | 19.1          | 17                   | 22.3          | 32.0          | 7                    | 26.7          | 30.9          | 6                             | 31.1          | 29.9          |
| Automobiles                                                                          | 22                                  | 54.6          | 401.0         | 9                    | 171.6         | 824.1         | 8                    | 159.6         | 627.4         | 12                            | 144.7         | 474.4         |
| Boots and shoes, not including rubber boots and shoes                                | 6                                   | 3.5           | 23.5          | 8                    | 11.9          | 40.6          | 9                    | 13.4          | 38.3          | 14                            | 15.9          | 34.6          |
| <i>Industries with products valued at \$100,000,000, but less than \$500,000,000</i> |                                     |               |               |                      |               |               |                      |               |               |                               |               |               |
| Printing and publishing, newspaper                                                   | 15                                  | 5.2           | 12.2          | 31                   | 32.6          | 38.4          | 10                   | 22.1          | 31.3          | 3                             | 18.8          | 29.2          |
| Bread and other bakery products                                                      | 13                                  | 23.8          | 23.3          | 12                   | 15.2          | 52.6          | 11                   | 23.9          | 47.2          | 10                            | 37.0          | 39.8          |
| Clothing, women's                                                                    | 8                                   | 9.9           | 32.9          | 15                   | 20.9          | 59.7          | 12                   | 23.2          | 55.4          | 9                             | 25.9          | 50.5          |
| Clothing, men's                                                                      | 7                                   | -9.1          | 39.4          | 18                   | -8.9          | 35.9          | 13                   | -5.7          | 36.5          | 8                             | -2.1          | 37.1          |
| Smelting and refining, copper                                                        | 74                                  | 13.5          | 22.6          | 5                    | 13.7          | 69.5          | 14                   | 17.2          | 57.6          | 40                            | 43.3          | 2.8           |
| Liquors, malt                                                                        | 24                                  | 13.7          | 13.4          | 30                   | 34.3          | 29.0          | 15                   | 18.0          | 25.3          | 5                             | 12.3          | 24.5          |
| Petroleum refining                                                                   | 9                                   | 82.1          | 16.9          | 7                    | 63.2          | 43.0          | 16                   | 67.2          | 35.4          | 33                            | 88.5          | 5.4           |
| Woolen and worsted goods                                                             | 59                                  | -2.8          | 14.9          | 16                   | -9.9          | 38.5          | 17                   | -9.6          | 36.3          | 20                            | -9.1          | 32.5          |
| Leather, tanned, curried, and finished                                               | 25                                  | 10.1          | 8.7           | 10                   | 14.5          | 29.9          | 18                   | 12.0          | 29.8          | 30                            | 4.2           | 29.5          |
| Electrical machinery, apparatus, and supplies                                        | 14                                  | 35.3          | 44.3          | 23                   | 42.5          | 62.4          | 19                   | 51.4          | 57.2          | 16                            | 60.0          | 52.4          |
| Paper and wood pulp                                                                  | 21                                  | 16.4          | 15.2          | 19                   | 28.9          | 48.7          | 20                   | 24.1          | 41.8          | 23                            | 16.4          | 32.0          |
| Iron and steel, blast furnaces                                                       | 50                                  | 23.6          | 9.6           | 13                   | -17.5         | 79.2          | 21                   | -18.8         | 68.8          | 44                            | -25.0         | 33.9          |
| Tobacco, cigars and cigarettes                                                       | 10                                  | 9.5           | 3.1           | 29                   | 27.1          | 26.6          | 22                   | 21.1          | 21.3          | 15                            | 17.1          | 18.1          |
| Lumber, planing-mill products                                                        | 20                                  |               |               | 21                   |               |               | 23                   |               |               | 22                            |               |               |
| Printing and publishing, book and job                                                | 16                                  | 4.1           | 23.9          | 39                   | 24.2          | 47.7          | 24                   | 22.5          | 37.4          | 11                            | 21.7          | 33.3          |
| Sugar, refining                                                                      | 101                                 | 19.7          |               | 14                   | 16.7          |               | 25                   | 16.6          |               | 75                            | 13.3          |               |
| Furniture                                                                            | 12                                  | 3.6           | 12.1          | 33                   | 17.0          |               | 26                   | 15.9          | 34.5          | 18                            | 15.1          | 29.4          |
| Hosiery and knit goods                                                               | 11                                  | 16.4          | 24.2          | 26                   | 33.1          | 43.6          | 27                   | 29.4          | 46.0          | 24                            | 24.8          | 49.1          |
| Silk goods, including throwsters                                                     | 17                                  | 9.2           | 24.4          | 27                   | 34.0          | 42.1          | 28                   | 29.0          | 47.7          | 25                            | 22.9          | 55.2          |
| Butter                                                                               | 87                                  | 22.4          | 21.3          | 20                   | 25.3          | 67.5          | 29                   | 24.8          | 64.5          | 68                            | 21.6          | 47.1          |
| <i>Rubber goods, not elsewhere specified</i>                                         |                                     |               |               |                      |               |               |                      |               |               |                               |               |               |
| Gas, illuminating and heating                                                        | 31                                  | 89.4          | 25.2          | 32                   | 53.4          | 111.2         | 30                   | 74.1          | 103.9         | 27                            | 110.8         | 92.0          |
| Food preparations, not elsewhere specified                                           | 38                                  | 17.7          | 21.8          | 43                   | 41.0          | 41.0          | 31                   | 32.0          | 33.3          | 19                            | 25.4          | 30.0          |
| Food preparations, not elsewhere specified                                           | 70                                  | 35.7          | 32.1          | 25                   | 83.2          | 122.8         | 32                   | 75.0          | 104.9         | 39                            | 58.5          | 76.0          |
| Oil, cottonseed, and cake                                                            | 65                                  | 27.8          | 9.9           | 22                   | 51.0          | 49.7          | 33                   | 43.5          | 53.4          | 67                            | 11.1          | 71.2          |
| <i>Liquors, distilled</i>                                                            |                                     |               |               |                      |               |               |                      |               |               |                               |               |               |
| Cars, steam-railroad, not including operations of railroad companies                 | 155                                 | -2.1          | 20.1          | 68                   | 14.0          | 40.4          | 34                   | 1.0           | 55.9          | 17                            | -1.7          | 59.7          |
| Tobacco, chewing and smoking, and snuff                                              | 27                                  | 26.0          | 26.5          | 28                   | 67.9          | 4.1           | 35                   | 57.4          | 11.3          | 41                            | 39.1          | 26.6          |
| Smelting and refining, lead                                                          | 58                                  | -4.6          | 13.5          | 44                   | 2.9           | 65.6          | 6                    | 11.9          | 34.1          | 26                            | 20.1          | 14.4          |
| Confectionery                                                                        | 137                                 | -0.5          | -2.0          | 24                   | 1.4           | -10.1         | 37                   | 2.5           | -9.9          | 98                            | 13.7          | -8.5          |
| Agricultural implements                                                              | 28                                  | 20.2          | 23.2          | 38                   | 24.5          | 66.3          | 38                   | 26.7          | 54.8          | 34                            | 30.2          | 40.2          |
| Brass, bronze, and copper products                                                   | 33                                  | -4.1          | 6.7           | 45                   | 21.9          | 24.9          | 39                   | 12.1          | 30.6          | 29                            | 5.3           | 35.0          |
| Structural ironwork, not made in steel works or rolling mills                        | 41                                  | -0.8          | 22.5          | 35                   | 16.4          | 51.1          | 40                   | 8.1           | 46.5          | 47                            | -8.0          | 38.1          |
| Chemicals                                                                            | 35                                  | 17.2          | 17.4          | 42                   | 14.3          | 61.6          | 41                   | 19.6          | 46.5          | 32                            | 26.8          | 30.1          |
| Fertilizers                                                                          | 46                                  | 36.2          | 19.6          | 40                   | 39.4          | 52.4          | 42                   | 34.2          | 36.2          | 36                            | 28.0          | 61.1          |
| Coffee and spice, roasting and grinding                                              | 62                                  | 24.6          | 29.1          | 36                   | 55.3          | 77.0          | 43                   | 47.4          | 83.9          | 49                            | 31.4          | 99.6          |
| Canning and preserving, fruits and vegetables                                        | 126                                 | 14.1          | 25.7          | 34                   | 40.0          | 26.4          | 44                   | 36.4          | 31.3          | 62                            | 25.3          | 49.0          |
| Brick and tile, terra-cotta, and fire-clay products                                  | 30                                  | 24.3          | 1.3           | 37                   | 65.2          | 21.2          | 45                   | 63.1          | 17.0          | 48                            | 58.8          | 8.6           |
| Automobile bodies and parts                                                          | 18                                  |               |               | 65                   |               |               | 46                   |               |               | 28                            |               |               |
| Soap                                                                                 | 34                                  | 95.6          | 1,249.6       | 49                   | 166.0         | 1,501.5       | 47                   | 134.0         | 1,534.3       | 38                            | 109.7         | 1,560.2       |
| Glass                                                                                | 86                                  | 9.0           | 17.7          | 41                   | 23.1          | 65.5          | 48                   | 14.9          | 63.1          | 58                            | -0.3          | 58.9          |
| Millinery and lace goods                                                             | 23                                  | 8.1           | 7.7           | 63                   | 43.3          | 22.8          | 49                   | 33.6          | 15.7          | 31                            | 28.5          | 12.2          |
| Paints                                                                               | 37                                  | 15.5          | 42.5          | 51                   | 28.1          | 71.5          | 50                   | 32.9          | 69.2          | 42                            | 38.3          | 66.0          |
| Dyeing and finishing textiles                                                        | 49                                  | 12.5          | 21.3          | 44                   | 14.6          | 34.9          | 51                   | 18.9          | 40.6          | 56                            | 27.1          | 53.1          |
| Marble and stone work                                                                | 32                                  | 10.0          | 23.8          | 52                   | 60.8          | 79.7          | 52                   | 30.8          | 64.3          | 45                            | 8.9           | 54.6          |
| Carriages and wagons                                                                 | 26                                  | -16.2         | 28.4          | 74                   | 1.1           | 40.8          | 53                   | -5.3          | 33.3          | 35                            | -8.5          | 29.9          |
| Patent medicines and compounds                                                       | 39                                  | -21.4         | -13.5         | 53                   | -18.3         | 4.4           | 54                   | -14.9         | 3.7           | 43                            | -11.3         | -4.1          |
| Cement                                                                               | 90                                  | 20.8          | 0.5           | 76                   | 33.6          | 26.3          | 55                   | 22.3          | 12.4          | 37                            | 17.0          | 6.9           |
|                                                                                      | 54                                  | 4.3           | 53.2          | 58                   | 77.2          | 104.2         | 56                   | 61.0          | 111.6         | 46                            | 47.0          | 91.8          |

\* A minus sign (-) denotes decrease.

\* Less than one-tenth of 1 per cent.

TABLE 6.

## SUMMARY FOR FOURTEEN GENERAL GROUPS OF INDUSTRIES: 1914, 1909, 1904, AND 1899

| Group                         | Cen-<br>sus<br>Year | Num-<br>ber of<br>Estab-<br>lish-<br>ments | Wage<br>Earners<br>(Average<br>Number) | Capital      | Wages       | Cost of<br>Materials | Value of<br>Products | Value<br>Added by<br>Manu-<br>facture |
|-------------------------------|---------------------|--------------------------------------------|----------------------------------------|--------------|-------------|----------------------|----------------------|---------------------------------------|
| Expressed in Thousands        |                     |                                            |                                        |              |             |                      |                      |                                       |
| All industries                | 1914                | 275,791                                    | 7,036,337                              | \$22,790,980 | \$4,078,332 | \$13,368,069         | \$24,246,435         | \$9,878,346                           |
|                               | 1909                | 268,491                                    | 6,613,491                              | 18,428,270   | 3,427,038   | 12,142,791           | 20,672,052           | 8,529,261                             |
|                               | 1904                | 216,180                                    | 5,468,383                              | 12,675,383   | 2,610,445   | 8,504,208            | 14,793,903           | 6,293,095                             |
|                               | 1899                | 207,514                                    | 4,712,765                              | 8,975,256    | 2,008,361   | 6,575,851            | 11,406,927           | 4,831,076                             |
| Chemicals and allied products | 1914                | 12,374                                     | 299,569                                | 3,034,209    | 167,494     | 1,289,348            | 2,001,634            | 712,285                               |
|                               | 1909                | 12,060                                     | 267,761                                | 2,167,425    | 129,003     | 931,045              | 1,526,599            | 595,534                               |
|                               | 1904                | 9,826                                      | 227,326                                | 1,388,328    | 102,388     | 635,919              | 1,075,191            | 441,600                               |
|                               | 1899                | 8,928                                      | 196,538                                | 1,163,816    | 77,560      | 451,457              | 761,691              | 310,234                               |

The 344 industries distinguished in the census of 1914 have been grouped into 14 general classes in order to facilitate comparison of one broad type with another. In Table 6 are given the figures for "all industries" and the group of "chemicals and allied products" for four census periods. In general the reader will observe in the chemical group a marked difference between the figures of the first two and last two periods, showing increases in the latter of 50 to 100 per cent or more. Thus, the number of establishments increased from 8928 in 1899 to 12,374 in 1914. Capital invested in-

facturing, if any, done in educational, eleemosynary and penal institutions.

#### BAKING POWDERS AND YEAST

This classification includes various compounds for raising bread, cake, and pastry, and dry, compressed, and liquid yeast. Table 106 shows separate statistics for the establishments whose chief product was baking powders and for those making yeast as the product of chief value. Many minor products were reported by the manufacturers of baking powder, such as bluing,

TABLE 106

| Industry                                              | Number of Establishments | Wage Earners (Average Number) | Chemicals and Allied Products: 1914 |           |                   |                   | Value Added by Manufacture |
|-------------------------------------------------------|--------------------------|-------------------------------|-------------------------------------|-----------|-------------------|-------------------|----------------------------|
|                                                       |                          |                               | Capital                             | Wages     | Cost of Materials | Value of Products |                            |
|                                                       |                          |                               | Expressed in thousands—             |           |                   |                   |                            |
| Total                                                 | 12,374                   | 299,569                       | \$3,034,209                         | \$167,494 | \$1,289,348       | \$2,001,634       | \$712,286                  |
| Baking powders and yeast.                             | 124                      | 2,270                         | 35,272                              | 1,241     | 10,895            | 22,339            | 11,444                     |
| Baking powders                                        | 105                      | 1,606                         | 28,375                              | 771       | 8,427             | 16,003            | 7,576                      |
| Yeast                                                 | 19                       | 664                           | 6,897                               | 470       | 2,468             | 6,336             | 3,868                      |
| Blackening, stains and dressings.                     | 197                      | 1,766                         | 4,986                               | 877       | 5,129             | 9,882             | 4,753                      |
| Bluing.                                               | 66                       | 254                           | 712                                 | 105       | 489               | 1,184             | 695                        |
| Bone, carbon and lamp black.                          | 27                       | 339                           | 4,995                               | 231       | 686               | 1,464             | 778                        |
| Bone black and lamp black                             | 7                        | 164                           | 656                                 | 114       | 263               | 535               | 272                        |
| Carbon black.                                         | 20                       | 175                           | 4,359                               | 117       | 423               | 929               | 506                        |
| Candles.                                              | 15                       | 387                           | 2,286                               | 183       | 1,119             | 1,731             | 612                        |
| Chemicals and acids.                                  | 427                      | 35,375                        | 259,580                             | 24,279    | 96,185            | 173,269           | 77,084                     |
| Chemicals.                                            | 395                      | 32,311                        | 224,346                             | 22,066    | 89,451            | 158,054           | 68,603                     |
| Sulphuric, nitric and mixed acids                     | 32                       | 3,064                         | 35,234                              | 2,213     | 6,734             | 15,215            | 8,481                      |
| Cleansing and polishing preparations                  | 398                      | 1,239                         | 5,898                               | 619       | 3,825             | 9,152             | 5,257                      |
| Cleansing preparations                                | 186                      | 601                           | 3,013                               | 296       | 2,047             | 5,045             | 2,908                      |
| Polishing preparations.                               | 212                      | 638                           | 2,885                               | 323       | 1,848             | 4,107             | 2,259                      |
| Coke, not including gas-house coke.                   | 231                      | 21,107                        | 161,561                             | 14,289    | 69,138            | 99,275            | 30,137                     |
| Drugs, etc.                                           | 3,844                    | 26,561                        | 136,156                             | 13,293    | 71,555            | 175,452           | 103,897                    |
| Drug grinding.                                        | 29                       | 1,059                         | 8,434                               | 583       | 5,215             | 8,080             | 2,865                      |
| Druggists' preparations.                              | 416                      | 9,277                         | 46,638                              | 4,755     | 22,935            | 48,010            | 25,075                     |
| Patent medicines and compounds.                       | 2,903                    | 13,328                        | 71,437                              | 6,675     | 35,940            | 102,463           | 66,523                     |
| Perfumery and cosmetics                               | 496                      | 2,897                         | 9,647                               | 1,280     | 7,465             | 16,899            | 7,454                      |
| Dye-stuffs and extracts.                              | 112                      | 2,839                         | 21,284                              | 1,613     | 13,238            | 20,620            | 7,382                      |
| Explosives.                                           | 111                      | 6,306                         | 71,351                              | 4,488     | 25,627            | 41,433            | 15,806                     |
| Fertilizers.                                          | 784                      | 22,515                        | 217,065                             | 10,532    | 107,955           | 155,196           | 45,241                     |
| Gas, illuminating and heating                         | 1,284                    | 43,792                        | 1,252,422                           | 26,802    | 76,799            | 220,238           | 143,459                    |
| Glue, not elsewhere specified.                        | 57                       | 3,129                         | 17,162                              | 1,854     | 9,368             | 13,733            | 4,365                      |
| Greases                                               | 446                      | 5,582                         | 22,368                              | 3,794     | 19,828            | 29,820            | 9,992                      |
| Grease and tallow, not including lubricating greases  | 369                      | 5,106                         | 18,928                              | 3,512     | 17,651            | 24,901            | 7,840                      |
| Soap stock.                                           | 107                      | 1,877                         | 6,993                               | 1,223     | 5,407             | 8,087             | 2,680                      |
| Tallow.                                               | 180                      | 1,750                         | 7,157                               | 1,249     | 8,412             | 11,389            | 2,977                      |
| All other.                                            | 82                       | 1,479                         | 4,778                               | 1,040     | 3,242             | 5,425             | 2,183                      |
| Lubricating greases                                   | 77                       | 476                           | 3,440                               | 282       | 2,767             | 4,919             | 2,152                      |
| Ink, printing.                                        | 70                       | 1,391                         | 11,943                              | 1,064     | 6,806             | 13,830            | 7,024                      |
| Ink, writing.                                         | 54                       | 512                           | 2,464                               | 263       | 1,236             | 2,784             | 1,548                      |
| Inks.                                                 | 1,193                    | 25,576                        | 187,193                             | 11,113    | 248,517           | 90,040            | 48,846                     |
| Cottonseed and cake                                   | 882                      | 21,810                        | 18,073                              | 8,490     | 1180,970          | 212,127           | 31,150                     |
| Essential.                                            | 105                      | 249                           | 1,617                               | 133       | 1,565             | 2,314             | 740                        |
| Linsed.                                               | 25                       | 1,488                         | 39,873                              | 1,127     | 39,555            | 44,882            | 5,327                      |
| Not elsewhere specified.                              | 181                      | 2,049                         | 27,630                              | 1,363     | 26,420            | 38,040            | 11,620                     |
| Fish.                                                 | 22                       | 420                           | 4,362                               | 217       | 3,470             | 4,370             | 900                        |
| Oil.                                                  | 5                        | 248                           | 837                                 | 171       | 1,807             | 2,295             | 488                        |
| All other.                                            | 154                      | 1,381                         | 22,431                              | 975       | 21,143            | 31,375            | 10,232                     |
| Paint and varnish.                                    | 800                      | 16,083                        | 129,534                             | 10,180    | 88,466            | 145,624           | 57,158                     |
| Paints                                                | 585                      | 13,349                        | 99,673                              | 8,751     | 71,588            | 112,400           | 40,831                     |
| Varnishes.                                            | 215                      | 2,734                         | 29,861                              | 1,865     | 16,878            | 33,215            | 16,337                     |
| Tar, pitch, rosin                                     | 176                      | 25,366                        | 325,646                             | 19,397    | 325,265           | 396,361           | 71,096                     |
| Salt                                                  | 98                       | 5,089                         | 33,151                              | 3,041     | 6,273             | 14,070            | 7,797                      |
| Soap                                                  | 371                      | 14,172                        | 92,872                              | 8,088     | 88,867            | 122,942           | 39,075                     |
| Turpentine and rosin                                  | 1,394                    | 34,817                        | 20,745                              | 8,583     | 5,536             | 20,990            | 15,454                     |
| Wood distillation, not including turpentine and rosin | 95                       | 2,782                         | 17,563                              | 1,565     | 6,496             | 9,882             | 3,386                      |

creased more than 100 per cent; cost of materials nearly 300 per cent; value of products nearly 300 per cent; and value added by manufacture over 200 per cent.

#### SCOPE OF THE CENSUS

As might easily be imagined, the officials in charge of the census are somewhat puzzled as to just what industries should be grouped in chemicals and allied products. Of necessity the decision must be more or less arbitrary, and as shown in Table 106 the group includes "not only the industries whose products are chemicals in the ordinary sense of that term, but also the industries which employ to a large extent chemical processes of manufacture." Table 106, in effect, is a detailed analysis of the summary figures for 1914 given in Table 6. The census did not cover establishments which were idle during the year or those which had a value of products of less than \$500; nor did it cover the manu-

facturing, chocolate, coffee, spice, confectionery, flavoring extracts, food preparations, and vinegar; while those making yeast also reported stock feed and alcohol.

In addition to the products covered by Table 106 baking powders to the value of \$1,867,674 were reported in 1914 as made for sale by establishments assigned to other industries, principally those grinding and roasting coffee and those manufacturing flavoring extracts. Yeast to the value of \$2,451,410 was reported as sold by distillers and manufacturers of vinegar. In 1909 baking powders and yeast to the value of \$3,963,573 were reported by establishments assigned to other industries. Many concerns make similar products for their own consumption in further processes of manufacture.

#### BLACKING, STAINS, AND DRESSINGS

Establishments in this industry manufacture principally blackings, waxes, stains, dressings, and polishes

for leather boots and shoes, harness and belting, stove polish, burnishing inks, and enameled carriage-top dressings, as well as pastes, washes, dyes, and gums.

In addition to the products covered by Table 106 blackings, stains and dressings to the value of \$377,617 in 1914 were reported by establishments assigned to other classifications, principally "mucilage and paste," "paints," "patent medicines and compounds," and "leather, tanned, curried, and finished."

#### BLUING

Establishments under this classification manufacture principally laundry bluing, soluble or liquid, aniline blue etc. The usual materials used in this manufacture are indigo and Prussian blue.

In addition to the products covered by Table 106 bluing to the value of \$269,199 in 1914 and of \$350,377 in 1909 was reported by establishments assigned to other classifications, principally "pickles, preserves, and sauces," "flavoring extracts," "patent medicines and compounds," and "coffee and spice, roasting and grinding."

#### BONE, CARBON AND LAMPBLACK

Establishments in this classification are engaged in the preparation of black pigments. There are three principal methods: The carbonization of bones in retorts, producing bone black or animal charcoal, also known technically as "char"; the deposition of carbon black by the imperfect combustion of natural gas, the flame impinging upon slate or metallic slabs or revolving cylinders; and the deposition of lampblack by the incomplete combustion of coal tar, wood tar, petroleum, rosin etc., the dense smoke depositing the soot in chambers. Some establishments make ivory black by the carbonization of scraps of animal teeth and tusks.

Table 106 shows statistics for "bone black and lampblack" and for "carbon black" separately, each establishment being classified according to its product of chief value. Table 107 presents the statistics of the production of bone black, carbon black, and lampblack by establishments in all industries for 1914 and 1909.

| TABLE 107                           | Bone, Carbon and Lamp Black |             |
|-------------------------------------|-----------------------------|-------------|
|                                     | 1914                        | 1909        |
| Total number of establishments..... | 39                          | 57          |
| Total value of products.....        | \$2,953,947                 | \$2,135,554 |
| Products                            |                             |             |
| Bone black (animal charcoal):       |                             |             |
| Number of establishments.....       | 7                           | 7           |
| Pounds.....                         | 44,509,000                  |             |
| Value.....                          | \$1,332,000                 | \$1,070,333 |
| Carbon black:                       |                             |             |
| Number of establishments.....       | 20                          | 18          |
| Pounds.....                         | 22,869,000                  |             |
| Value.....                          | \$916,091                   | \$625,514   |
| Lampblack:                          |                             |             |
| Number of establishments.....       | 12                          | 32          |
| Value.....                          | \$503,856                   | \$439,707   |

<sup>1</sup> Includes \$215,212 the value of 4,786,394 pounds, and \$288,644 for which no quantity was reported

#### CANDLES

The principal products of establishments under this classification are candles of all descriptions made of tallow, paraffin, stearin, and wax. In addition to the products covered by Table 106 candles were reported in 1914 by petroleum refineries to the value of \$1,402,945 and by soap manufacturers to the value of \$150,492, while establishments assigned to other classifications, principally chemicals, reported candles to the value of \$411,631. The candles made by petroleum refineries were

not reported separately in 1909, and the amount cannot be stated, but candles to the value of \$527,910 were reported by establishments engaged primarily in the manufacture of "soap," "chemicals" and "oil, not elsewhere specified."

#### CHEMICALS AND ACIDS

Prior to the census of 1904 the general statistics for chemicals, sulphuric, nitric, and mixed acids, and wood distillation were included under the single classification of "Chemicals." For the censuses of 1904, 1909, and 1914, the three have been shown separately and a segregation of data made for 1899 for comparison. The statistics for wood distillation products are given in Table 122.

TABLE 122

| WOOD DISTILLATION                                        |  | 1914          | 1909             |
|----------------------------------------------------------|--|---------------|------------------|
| Number of establishments.....                            |  | 101           | 136              |
| Wood distillation industry.....                          |  | 95            | 120              |
| Manufacturing subsidiary wood distillation products..... |  | 6             | 16               |
| Number producing crude alcohol.....                      |  | 80            | 98               |
| Number producing refined alcohol.....                    |  | 16            | 17               |
| Number distilling pine wood.....                         |  | 15            | 33               |
| Wood, cords.....                                         |  | 1,042,517     | \$1,265,157      |
| Hardwoods.....                                           |  | 970,308       | 1,149,847        |
| Pine.....                                                |  | 72,209        | 115,310          |
| Crude wood alcohol.....                                  |  |               |                  |
| Consumed, gallons.....                                   |  | 7,388,902     | 9,670,497        |
| Purchased—                                               |  |               |                  |
| Gallons.....                                             |  | 5,565,446     | 7,135,464        |
| Cost.....                                                |  | \$1,408,124   | \$1,784,023      |
| Made and consumed, gallons.....                          |  | 1,823,456     | 2,534,889        |
| Products.....                                            |  |               |                  |
| Total value.....                                         |  | \$10,529,829  | \$10,312,657     |
| Wood distillation industry.....                          |  | \$9,882,537   | \$9,736,998      |
| Subsidiary products, other industries.....               |  | \$647,292     | \$575,659        |
| Wood alcohol:                                            |  |               |                  |
| Crude, gallons.....                                      |  | 9,020,431     | 9,307,583        |
| For sale.....                                            |  |               |                  |
| Gallons.....                                             |  | 7,196,975     | 6,772,700        |
| Value.....                                               |  | \$1,605,880   | \$1,774,459      |
| Made and consumed, gallons.....                          |  | 1,823,456     | 2,534,889        |
| Refined, gallons.....                                    |  | 6,464,955     |                  |
| For sale.....                                            |  |               |                  |
| Gallons.....                                             |  | 6,235,113     | 6,732,877        |
| Value.....                                               |  | \$2,709,369   | \$3,096,808      |
| Made and consumed, gallons.....                          |  | 229,842       | ( <sup>1</sup> ) |
| Acetate of lime, pounds.....                             |  | \$166,084,523 |                  |
| For sale.....                                            |  |               |                  |
| Pounds.....                                              |  | 163,521,577   | 141,478,296      |
| Value.....                                               |  | \$2,138,909   | \$2,118,443      |
| Made and consumed, pounds.....                           |  | 2,562,946     | ( <sup>2</sup> ) |
| Turpentine:                                              |  |               |                  |
| Gallons.....                                             |  | 575,575       | 706,868          |
| Value.....                                               |  | \$194,183     | \$249,526        |
| Tar, gallons.....                                        |  | 2,794,881     |                  |
| For sale.....                                            |  |               |                  |
| Gallons.....                                             |  | 1,306,324     | 1,302,257        |
| Value.....                                               |  | \$174,154     | \$113,225        |
| Made and consumed, gallons.....                          |  | 1,488,557     | ( <sup>3</sup> ) |
| Wood crocote:                                            |  |               |                  |
| Pounds.....                                              |  | 2,073,057     | 2,549,190        |
| Value.....                                               |  | \$38,872      | \$34,645         |
| Charcoal:                                                |  |               |                  |
| Bushels.....                                             |  | 44,450,485    | 39,952,235       |
| Value.....                                               |  | \$2,801,401   | \$2,426,644      |
| Rosin:                                                   |  |               |                  |
| Barrels.....                                             |  | 451,825       | ( <sup>4</sup> ) |
| Value.....                                               |  | \$198,165     |                  |
| Other wood distillation products.....                    |  | \$441,390     | \$231,192        |
| All other products.....                                  |  | \$227,497     | \$267,711        |

#### DISTILLATION EQUIPMENT

|                                |        |        |
|--------------------------------|--------|--------|
| Aggregate capacity, cords..... | 26,707 | 24,594 |
| Retorts:                       |        |        |
| Number.....                    | 794    | 1,448  |
| Capacity, cords.....           | 1,850  | 2,703  |
| Ovens:                         |        |        |
| Number.....                    | 228    | 177    |
| Capacity, cords.....           | 1,717  | 1,080  |
| Kilns:                         |        |        |
| Number.....                    | 326    | 310    |
| Capacity, cords.....           | 23,140 | 20,811 |

<sup>1</sup> Forest Products of the United States, 1909, p. 163; includes some wood used in charcoal burning.

<sup>2</sup> Figures not available.

<sup>3</sup> Total production of acetate of lime.

<sup>4</sup> Total production of turpentine and rosin, all industries; turpentine, 27,648,939 gallons; rosin, 2,944,929 barrels.

<sup>5</sup> Total value of products of the charcoal industry and of charcoal made for sale in other industries, \$3,209,628.

<sup>6</sup> Includes acetic acid, acetate of soda, acetone, formaldehyde, pyrolytic iron, and wood ashes. Total production for sale by all industries, of acetone, 10,425,817 pounds, value \$1,090,583; acetic acid, 70,617,637 pounds, value \$1,272,294; formaldehyde, 8,426,247 pounds, value \$655,174.

<sup>7</sup> In some cases equipment was reported as retorts at one census and ovens at another census.



Although the manufacture of sulphuric, nitric, and mixed acids is in the main a specialized industry, there is a considerable production by establishments that also manufacture other chemicals, and a large quantity of sulphuric acid is made in conjunction with the fertilizer industry. Hence, in Table 106, which presents in detail the statistics for materials and products for 1914 in comparison with those for 1909, 1904, and 1899, the statistics for sulphuric, nitric, and mixed acids are included along with those for other acids. At prior censuses establishments engaged in the manufacture of supplies for calcium lights, chiefly lime cylinders, and oxygen gas, constituted a separate industry, but these are now included under chemicals.

The chemical products are classified under 12 groups: (1) acids; (2) sodas and sodium compounds; (3) potash and potassium salts; (4) alums; (5) coal-tar products; (6) cyanides; (7) bleaching materials; (8) chemical substances produced by the aid of electricity, including those belonging under other groups; (9) plastics; (10) compressed or liquified gases; (11) fine chemicals; and (12) chemicals, not otherwise specified, such as glycerin, cream of tartar, epsom salts, blue vitriol, copperas etc.

The schedule used in taking the census named, under the various groups, the chemicals which at prior censuses had been reported by three or more establishments, and provided for the reporting in detail of such other chemicals as were manufactured. In some cases, however, manufacturers did not separately report all products, consequently there results a large amount of unclassified chemicals, which may include a considerable production of some of those for which detail figures are given and undoubtedly include others which could have been shown if they had been separately reported. The production is shown for all chemicals that can be separately given without the disclosure of individual operations, and those separately returned, but which can not be individually given, are named and reported as a whole under the several groups.

Many establishments distilling coal tar consume part of the product in the manufacture of roofing paper, roofing felt etc., and hence are classified as engaged in other industries, and their coal-tar production is not included under Group 5. Except as stated, where the production made and consumed is given, the figures refer to the quantity and value of the product made for sale and do not include that made and consumed in the same plant.

With respect to the group of products produced by the aid of electricity (Group 8) it should be said that many of the electrochemical and electrometallurgical products have, until recent years, been under the protection of patents, and detail statistics of production cannot be given for some of the most important without disclosing the operations of individual establishments.

Under plastics (Group 9) there is included pyroxylin plastics, sold under such trade names as celluloid, fibroloid, viscoloid, pegamoid, pyrolyn, xylonite etc.; pyroxylin or soluble cotton; viscose; artificial silk; phenolic condensation plastics, such as bakelite and condensite; rubber substitutes and all plastics formed by using caoutchouc, gutta-percha, casein, fibrin, gluten, gums, and glue, or other cementing materials by which sawdust, woodpulp, bonedust, zinc oxide, antimony, kaolin,

TABLE 108

THE CHEMICAL INDUSTRY, INCLUDING SULPHURIC, NITRIC, AND MIXED ACIDS (TONS OF 2,000 POUNDS)

|                                                               | 1914          | 1909             |
|---------------------------------------------------------------|---------------|------------------|
| Number of establishments.....                                 | 754           | 850              |
| The chemical industry.....                                    | 395           | 359              |
| Sulphuric, nitric, and mixed-acids industry.....              | 32            | 42               |
| Manufacturing subsidiary chemical products.....               | 327           | 449              |
| <b>Materials</b>                                              |               |                  |
| Total cost.....                                               | \$96,185,122  | \$69,531,257     |
| The chemical industry.....                                    | \$89,450,694  | \$64,145,429     |
| Sulphuric, nitric, and mixed-acids industry.....              | \$6,734,428   | \$5,385,828      |
| Sulphur or brimstone:.....                                    |               |                  |
| Tons.....                                                     | 56,296        | 77,450           |
| Cost.....                                                     | \$1,162,632   | \$1,433,743      |
| Pyrites:.....                                                 |               |                  |
| Tons.....                                                     | 889,695       | 597,691          |
| Cost.....                                                     | \$3,769,467   | \$3,170,188      |
| Nitrate of soda:.....                                         |               |                  |
| Tons.....                                                     | 58,101        | 52,976           |
| Cost.....                                                     | \$2,696,172   | \$2,373,220      |
| Sulphuric acid:.....                                          |               |                  |
| Tons.....                                                     | 264,774       | 58,552           |
| Cost.....                                                     | \$1,515,982   | \$564,390        |
| Nitric acid:.....                                             |               |                  |
| Tons.....                                                     | 7,819         | 1,525            |
| Cost.....                                                     | \$641,405     | \$139,591        |
| Mixed acid:.....                                              |               |                  |
| Tons.....                                                     | 6,015         | 4,546            |
| Cost.....                                                     | \$698,664     | \$335,672        |
| Ammonium sulphate:.....                                       |               |                  |
| Tons.....                                                     | 9,586         | 1,675            |
| Cost.....                                                     | \$567,249     | \$88,013         |
| Alcohol:.....                                                 |               |                  |
| Gallons.....                                                  | 296,886       | 479,428          |
| Cost.....                                                     | \$145,066     | \$287,416        |
| Wood:.....                                                    |               |                  |
| Gallons.....                                                  | 1,464,273     | 949,212          |
| Cost.....                                                     | \$577,122     | \$378,077        |
| Fuel and rent of power.....                                   | \$11,854,901  | \$8,566,294      |
| All other materials.....                                      | \$72,556,462  | \$52,202,083     |
| <b>Products</b>                                               |               |                  |
| Total value.....                                              | \$200,195,835 | \$150,580,149    |
| The chemical industry, all products.....                      | \$158,053,602 | \$117,741,103    |
| Sulphuric, nitric, and mixed acid industry, all products..... | 15,215,474    | 9,884,057        |
| Subsidiary chemical products of other industries.....         | 26,926,759    | 22,954,989       |
| <b>I.—Acids</b>                                               |               |                  |
| Total value.....                                              | \$30,516,569  | \$23,722,874     |
| Sulphuric acid:.....                                          |               |                  |
| Number of establishments.....                                 | 194           | 183              |
| Production reduced to 50° Baumé acid:.....                    |               |                  |
| Total tons.....                                               | 4,047,982     | 2,764,455        |
| For sale.....                                                 | 2,338,284     | 1,479,200        |
| Made and consumed, tons.....                                  | \$15,395,133  | \$10,103,425     |
| Production according to strength—                             | 1,709,698     | 1,285,255        |
| 50° Baumé.....                                                |               |                  |
| Total, tons.....                                              | 1,677,649     | 1,643,281        |
| For sale.....                                                 | \$71,121      | \$28,013         |
| Made and consumed, tons.....                                  | \$2,709,350   | \$3,176,450      |
| 60° Baumé.....                                                | 1,226,528     | 1,115,018        |
| Total, tons.....                                              | 795,489       | 189,384          |
| For sale.....                                                 | 545,562       | 177,414          |
| Made and consumed, tons.....                                  | \$3,754,866   | \$1,038,358      |
| 66° Baumé.....                                                | 249,927       | 11,970           |
| Total, tons.....                                              | 828,466       | 552,619          |
| For sale.....                                                 | 732,186       | 453,370          |
| Made and consumed, tons.....                                  | \$8,042,422   | \$5,454,002      |
| Oleum or fuming, and sulphur trioxide.....                    | 96,280        | 99,249           |
| Total, tons.....                                              | 77,758        | 32,337           |
| For sale.....                                                 | \$2,754       | \$28,594         |
| Made and consumed, tons.....                                  | \$888,495     | \$434,635        |
| Oleum or fuming, and sulphur trioxide.....                    | 15,404        | 3,743            |
| Reclaimed acid:.....                                          |               |                  |
| Tons.....                                                     | 136,360       | 7,069            |
| Value.....                                                    | \$518,890     | \$62,935         |
| Nitric acid:.....                                             |               |                  |
| Number of establishments.....                                 | 52            | 25               |
| Total production, tons.....                                   | 78,589        | 68,717           |
| For sale.....                                                 | 14,685        | 13,663           |
| Made and consumed, tons.....                                  | \$1,591,625   | \$1,357,098      |
| Mixed acid (sulphuric-nitric).....                            | 63,904        | 55,054           |
| Number of establishments.....                                 | 37            | 14               |
| Total productions, tons.....                                  | 112,124       | 28,591           |
| For sale.....                                                 | \$2,204,480   | \$1,860,767      |
| Made and consumed, tons.....                                  | 69,399        | ( <sup>1</sup> ) |
| Acetic acid:.....                                             |               |                  |
| Number of establishments.....                                 | 13            | 13               |
| Total production, pounds.....                                 | 75,303,375    | 58,000,602       |
| For sale.....                                                 | 70,617,637    | 56,923,773       |
| Made and consumed, pounds.....                                | \$1,272,294   | \$1,336,874      |
| Oleum or fuming, and sulphur trioxide.....                    | 4,685,738     | 1,076,829        |

<sup>1</sup> Figures not available.

<sup>2</sup> Does not include materials used in chemical manufacture by establishments producing chemicals as subsidiary products.

<sup>3</sup> See Note 6.

<sup>4</sup> Includes oleum, in 1914, 60,963 tons; and in 1909, 27,602 tons, converted, above, to 50° acid at 1.71; and sulphur trioxide, in 1914, 1,391 tons; and in 1909 992 tons, converted, above, to 50° acid at 1.93.

TABLE 108 (Continued)

| Products                                         |              |                  | Products                                                                                              |               |                  |
|--------------------------------------------------|--------------|------------------|-------------------------------------------------------------------------------------------------------|---------------|------------------|
| I.—Acids (Continued)                             |              |                  | III.—Potash and Potassium Salts (Continued)                                                           |               |                  |
|                                                  | 1914         | 1909             |                                                                                                       | 1914          | 1909             |
| Boric acid:                                      |              |                  | Potassium nitrate (saltpeter):                                                                        |               |                  |
| Number of establishments.....                    | 5            | 5                | Tons.....                                                                                             | 14,740        |                  |
| Total production, pounds.....                    | 8,590,311    | 5,554,914        | Value.....                                                                                            | \$1,244,051   | ( <sup>1</sup> ) |
| For sale.....                                    | \$388,981    | \$295,776        | Caustic potash and potassium salts—bicarbonate, chloride, iodide, citrate, acetate, silicate, etc.... | \$2,801,225   | ( <sup>1</sup> ) |
| Made and consumed, pounds.....                   | 6,000        | ( <sup>1</sup> ) |                                                                                                       |               |                  |
| Citric acid:                                     |              |                  | IV.—Alums                                                                                             |               |                  |
| Number of establishments.....                    | 3            | 5                | Number of establishments.....                                                                         | 19            | 19               |
| Total production, pounds.....                    | 2,729,943    | 2,102,256        | Pounds.....                                                                                           | 313,712,000   | 276,294,000      |
| For sale.....                                    | \$2,657,840  | \$777,235        | Value.....                                                                                            | \$3,467,969   | \$3,022,355      |
| Made and consumed, pounds.....                   | 72,103       | ( <sup>1</sup> ) |                                                                                                       |               |                  |
| Hydrofluoric acid:                               |              |                  | Aluminum sulphate:                                                                                    |               |                  |
| Number of establishments.....                    | 9            | 10               | Pounds.....                                                                                           | 142,438,000   | 100,595,000      |
| Total production, pounds.....                    | 7,209,248    | 8,027,290        | Value.....                                                                                            | \$1,277,836   | \$843,956        |
| For sale.....                                    | \$373,637    | \$642,914        | Alum cake:                                                                                            |               |                  |
| Made and consumed, pounds.....                   | \$325,540    | \$294,379        | Pounds.....                                                                                           | 23,338,000    | 27,001,000       |
| Muriatic acid:                                   |              |                  | Value.....                                                                                            | \$251,186     | \$274,307        |
| Number of establishments.....                    | 31           | 38               | Concentrated alum:                                                                                    |               |                  |
| Total production, pounds.....                    | 337,167,882  | \$244,734,217    | Pounds.....                                                                                           | 42,562,000    | 54,879,000       |
| For sale.....                                    | \$1,348,805  | \$1,758,335      | Value.....                                                                                            | \$450,730     | \$468,795        |
| Made and consumed, pounds.....                   | 166,291,044  | 41,519,338       | Burnt alum:                                                                                           |               |                  |
| Oleic acid:                                      |              |                  | Pounds.....                                                                                           | 22,629,000    | 11,746,000       |
| Number of establishments.....                    | 7            | 8                | Value.....                                                                                            | \$364,656     | \$209,904        |
| Total production, pounds.....                    | 23,187,579   | 16,377,063       | Potash alum:                                                                                          |               |                  |
| For sale.....                                    | \$1,301,353  | \$845,106        | Pounds.....                                                                                           | 12,765,000    | 10,254,000       |
| Made and consumed, pounds.....                   | 1,254,843    | ( <sup>1</sup> ) | Value.....                                                                                            | \$219,768     | \$153,319        |
| Phosphoric acid:                                 |              |                  | Soda alum:                                                                                            |               |                  |
| Number of establishments.....                    | 7            | 9                | Pounds.....                                                                                           | \$13,995,000  | \$98,062,000     |
| Production for sale—                             |              |                  | Value.....                                                                                            | \$254,477     | \$133,941        |
| Pounds.....                                      | 12,420,191   | ( <sup>1</sup> ) | Other alums—porous, excelsior, pearl, ammonium, chloride of alumina, etc.                             |               |                  |
| Value.....                                       | \$680,239    | \$667,505        | Pounds.....                                                                                           | 55,985,000    | \$63,757,000     |
| Stearic acid:                                    |              |                  | Value.....                                                                                            | \$649,116     | \$936,133        |
| Number of establishments.....                    | 10           | 11               | V.—Coal-tar product                                                                                   |               |                  |
| Total production, pounds.....                    | 14,960,109   | ( <sup>1</sup> ) | Number of establishments.....                                                                         | 40            | 42               |
| For sale.....                                    | \$1,242,492  | \$1,143,123      | Coal-tar distillery products, value                                                                   | \$58,065,156  | \$4,057,591      |
| Made and consumed, pounds.....                   | 608,705      | ( <sup>1</sup> ) | Chemicals or medicinal preparations from coal-tar, value                                              | \$774,350     | \$228,528        |
| Tannic acid:                                     |              |                  |                                                                                                       |               |                  |
| Number of establishments.....                    | 51           |                  | VI.—Cyanides                                                                                          |               |                  |
| Production for sale—                             |              |                  | Number of establishments.....                                                                         | 6             | 7                |
| Pounds.....                                      | 853,830      | ( <sup>1</sup> ) | Pounds.....                                                                                           | \$16,450,225  | \$13,291,080     |
| Value.....                                       | \$287,142    | \$3,220,206      | Value.....                                                                                            | \$2,398,674   | \$1,941,893      |
| Fatty acids.....                                 | \$206,576    |                  | Yellow prussiate of potash:                                                                           |               |                  |
| Miscellaneous acids.....                         | \$1,977,131  |                  | Pounds.....                                                                                           | 3,204,684     | 3,510,208        |
| Unclassified acids.....                          | \$59,552     |                  | Value.....                                                                                            | \$451,092     | \$463,981        |
|                                                  |              |                  | All other—sodium cyanide, metallocyanides, yellow prussiate of soda, trisalts, and potassium cyanide: |               |                  |
| II.—Sodas and sodium compounds                   |              |                  | Pounds.....                                                                                           | 13,245,541    | 9,780,672        |
| Sodas:                                           |              |                  | Value.....                                                                                            | \$1,947,582   | \$1,477,910      |
| Number of establishments.....                    | 69           | 70               | VII.—Bleaching materials                                                                              |               |                  |
| Value.....                                       | \$23,632,704 | \$23,368,509     | Number of establishments.....                                                                         | 56            | 48               |
| Bicarbonate of soda:                             |              |                  | Value of products.....                                                                                | \$5,302,359   | \$3,215,728      |
| Tons.....                                        | 90,169       | 82,800           | Hypochlorites—chiefly chloride of lime and bleaching powder:                                          |               |                  |
| Value.....                                       | \$1,439,014  | \$1,515,045      | Number of establishments.....                                                                         | 14            | 9                |
| Caustic soda—                                    |              |                  | Pounds.....                                                                                           | 310,380,000   | 116,802,000      |
| Tons.....                                        | 212,539      | 131,612          | Value.....                                                                                            | \$2,916,225   | \$1,786,846      |
| Value.....                                       | \$6,657,514  | \$5,264,887      | Hydrogen peroxide:                                                                                    |               |                  |
| Salt soda, including monohydrate crystals—       |              |                  | Number of establishments.....                                                                         | 20            | 17               |
| Tons.....                                        | 106,591      | 86,644           | Pounds.....                                                                                           | \$432,595,000 | \$49,926,000     |
| Value.....                                       | \$1,510,449  | \$1,156,882      | Value.....                                                                                            | \$1,303,596   | \$870,541        |
| Soda ash—                                        |              |                  | Bisulphite of soda, lime, etc.:—                                                                      |               |                  |
| Tons.....                                        | 935,305      | 646,057          | Number of establishments.....                                                                         | 14            | 15               |
| Value.....                                       | \$10,937,945 | \$10,362,656     | Pounds.....                                                                                           | 26,346,000    | 31,718,000       |
| Borax—                                           |              |                  | Value.....                                                                                            | \$243,559     | \$226,154        |
| Tons.....                                        | 26,501       | 20,154           | Chlorine:                                                                                             |               |                  |
| Value.....                                       | \$2,071,774  | \$1,756,922      | Number of establishments.....                                                                         | 7             |                  |
| Soda products not classified                     |              |                  | Pounds.....                                                                                           | 12,217,000    |                  |
| Sodium:                                          |              |                  | Value.....                                                                                            | \$472,836     | \$332,187        |
| Phosphat.....                                    | 15,397       | 12,290           | All other—sodium peroxide, sulphur dioxide, lime sulphur solutions, etc.....                          | \$366,143     |                  |
| Tons.....                                        | \$853,528    | \$540,282        | VIII.—Chemical substances produced by the aid of electricity <sup>1</sup>                             |               |                  |
| Silicate.....                                    | 169,049      | 34,170           | Number of establishments.....                                                                         | 36            | 134              |
| Value.....                                       | \$1,648,854  | \$366,621        | Value of products.....                                                                                | \$29,661,949  | \$18,451,461     |
| Sulphides.....                                   | 20,263       | 7,673            | Chlorates:                                                                                            |               |                  |
| Value.....                                       | \$516,644    | \$206,450        | Number of establishments.....                                                                         | 5             | 5                |
| Sulphat.....                                     |              |                  | Tons.....                                                                                             | 8,304         | 5,285            |
| Glauber salts.....                               | 34,537       | 46,471           | Value.....                                                                                            | \$1,131,316   | \$904,550        |
| Tons.....                                        | \$427,806    | \$512,464        | Hypochlorites:                                                                                        |               |                  |
| Salt cake.....                                   | 90,442       | ( <sup>1</sup> ) | Number of establishments.....                                                                         | 4             | 5                |
| Value.....                                       | \$841,887    | ( <sup>1</sup> ) | Tons.....                                                                                             | 73,197        | 45,976           |
| Bichromate.....                                  | 11,824       | ( <sup>1</sup> ) | Value.....                                                                                            | \$1,714,837   | \$1,506,831      |
| Tons.....                                        | \$1,125,398  | ( <sup>1</sup> ) | Caustic soda, caustic potash, and lye:                                                                |               |                  |
| Value.....                                       | \$61,490     | ( <sup>1</sup> ) | Number of establishments.....                                                                         | 6             |                  |
| Benzoin.....                                     | \$86,649     | ( <sup>1</sup> ) | Tons.....                                                                                             | 48,663        |                  |
| Sulphite.....                                    | \$768,157    | ( <sup>1</sup> ) | Value.....                                                                                            | \$2,309,811   |                  |
| Other sodium compounds.....                      | \$2,447,406  | ( <sup>1</sup> ) | Iron and other alloys <sup>2</sup> :                                                                  |               |                  |
| Lye                                              |              |                  | Number of establishments.....                                                                         | 7             |                  |
| Soda washing compounds, not including soap—      | 12,441       | ( <sup>1</sup> ) | Value.....                                                                                            | \$2,859,482   |                  |
| Tons.....                                        | \$204,230    | ( <sup>1</sup> ) |                                                                                                       |               |                  |
| Value.....                                       |              |                  |                                                                                                       |               |                  |
| III.—Potash and potassium salt                   |              |                  |                                                                                                       |               |                  |
| Number of establishments.....                    | 42           | 31               |                                                                                                       |               |                  |
| Products, value.....                             | \$4,094,927  |                  |                                                                                                       |               |                  |
| Crude potash.....                                | \$30,644     | \$88,940         |                                                                                                       |               |                  |
| Potassium carbonate (unrefined and refined)..... | \$19,007     |                  |                                                                                                       |               |                  |

\* Includes considerable quantities of the acids for which statistics are given above, notably sulphuric, nitric, mixed, acetic and muriatic acids, which a few establishments reported in lump without classification according to kind.

<sup>1</sup> Includes the following acids, in order named as to value: Tartaric, carbonic, picric, salicylic, lactic, oxalic, hydrofluosilicic, pyrogallic, gallic, pyroglucous, hypophosphorous, benzoic and arsenic.

<sup>2</sup> Number manufacturer, bicarbonate, caustic, salt soda, soda ash or borax in 1914 and 1909; and same not including borax in 1904 and 1899.

<sup>3</sup> Includes the following sodium compounds in order named as to value: Hyposulphite, sesquicarbonate, acetate, nitrate, perchlorate, bromide, iodide, fluoride, bisulphate, citrate, diamide and oxalate.

<sup>1</sup> Includes sodium aluminum sulphate.

<sup>2</sup> Includes 38,342,000 pounds of unclassified alums.

<sup>3</sup> Not including value of 109,901,315 gallons of tar, \$2,867,274, produced by by-product coke ovens; of 125,938,607 gallons of tar, \$3,252,756, produced by gas plants; and of coal-tar dyes and intermediates, \$4,652,947, made largely from stock of foreign origin.

<sup>4</sup> In addition, 1,239,382 pounds of cyanide blues, reported as Prussian blue, valued at \$387,077, were manufactured by 15 establishments engaged primarily in the manufacture of paints and pigments.

<sup>5</sup> Quantities not comparable because of lack of uniformity in strength of solutions.

<sup>6</sup> The statistics for products reported under other groups cover total production, inclusive of that made with the aid of electricity, and here included to the extent of \$5,042,281 in 1914, and \$2,539,478 in 1909.

<sup>7</sup> Includes number and output of one establishment engaged in the preparation of alumina.

<sup>8</sup> In addition, there were made in electric furnaces in 1914 by 14 establishments in the iron and steel industry, 21,548 tons of foundry iron and steel ingots and castings, chiefly direct steel castings.

TABLE 108 (Continued)

## VIII.—Chemical Substances Produced by the Aid of Electricity (Continued)

|                                                                                                                                                                                      | 1914         | 1909         |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------|--------------|
| Oxygen and hydrogen:                                                                                                                                                                 |              |              |
| Number of establishments.                                                                                                                                                            | 5            |              |
| Value.                                                                                                                                                                               | \$68,441     | \$16,040,080 |
| All other, named in order of value—aluminum, calcium carbide, abrasives, electrodes, sodium and sodium peroxide, phosphorus, silicon, chlorine, carbon bisulphide, and muriatic acid | \$21,578,062 |              |

## IX.—Plastics

|                                                                                                   | 1914         | 1909        |
|---------------------------------------------------------------------------------------------------|--------------|-------------|
| Number of establishments.                                                                         | 24           | 24          |
| Value of products.                                                                                | \$13,895,784 | \$7,472,732 |
| Pyrosilin, including goods sold under trade names—celluloid, fiberloid, viscoloid, xylonite, etc. | \$8,876,509  | \$5,682,379 |
| In partially manufactured form—rods, sheets, blocks, etc.                                         | \$3,778,374  | (1)         |
| Finished goods, manufactured in the producing establishments.                                     | \$5,098,135  | (1)         |
| Rubber substitutes, including finished goods                                                      | \$428,605    |             |
| Other plastics, including artificial silk.                                                        | \$4,590,670  | \$1,790,353 |

X.—Compressed or liquefied gases<sup>18</sup>

|                                                          | 1914        | 1909        |
|----------------------------------------------------------|-------------|-------------|
| Total value.                                             | \$7,624,884 | \$5,165,795 |
| Anhydrous ammonia (NH <sub>3</sub> ) <sup>19</sup>       |             |             |
| Number of establishments.                                | 14          | 15          |
| Pounds.                                                  | 16,659,789  | 11,969,846  |
| Value.                                                   | \$3,140,848 | \$2,544,238 |
| Carbonic acid gas, or carbon dioxide (CO <sub>2</sub> ): |             |             |
| Number of establishments.                                | 38          | 35          |
| Pounds.                                                  | 50,445,779  | 47,953,291  |
| Value.                                                   | \$2,320,685 | \$2,345,743 |
| Laughing gas, or nitrous oxide (N <sub>2</sub> O):       |             |             |
| Number of establishments.                                | 7           | 7           |
| Gallons.                                                 | 201,783,000 | 229,175     |
| Value.                                                   | \$213,099   | \$38,589    |
| Oxygen:                                                  |             |             |
| Number of establishments.                                | 51          | 20          |
| Cubic feet <sup>20</sup> .                               | 104,714,000 | 3,814,000   |
| Value.                                                   | \$1,829,446 | \$177,469   |
| Hydrogen:                                                |             |             |
| Number of establishments.                                | 6           |             |
| Cubic feet <sup>21</sup> .                               | 1,669,000   |             |
| Value.                                                   | \$16,671    | \$59,756    |
| Other gases—Cyanogen, nitrogen and liquid air.           |             |             |
| Number of establishments.                                | 10          |             |
| Value.                                                   | \$104,135   |             |

## XI.—Fine chemicals

|                                                                                                                                                                                                                                              | 1914         | 1909         |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------|--------------|
| Total value.                                                                                                                                                                                                                                 | \$10,983,017 | \$10,267,252 |
| Alkaloids:                                                                                                                                                                                                                                   |              |              |
| Ounces.                                                                                                                                                                                                                                      | 5,805,212    | 3,482,617    |
| Value.                                                                                                                                                                                                                                       | \$3,738,335  | \$3,188,914  |
| Amylacetate:                                                                                                                                                                                                                                 |              |              |
| Pounds.                                                                                                                                                                                                                                      | 1,300,052    | 1,470,568    |
| Value.                                                                                                                                                                                                                                       | \$465,664    | \$442,771    |
| Chloroform:                                                                                                                                                                                                                                  |              |              |
| Pounds.                                                                                                                                                                                                                                      | 1,333,954    | 1,869,685    |
| Value.                                                                                                                                                                                                                                       | \$295,317    | \$477,538    |
| Ether: <sup>22</sup>                                                                                                                                                                                                                         |              |              |
| Pounds.                                                                                                                                                                                                                                      | 2,120,082    | 1,168,631    |
| Value.                                                                                                                                                                                                                                       | \$278,816    | \$190,164    |
| Gold salts:                                                                                                                                                                                                                                  |              |              |
| Ounces.                                                                                                                                                                                                                                      | 28,817       | 42,544       |
| Value.                                                                                                                                                                                                                                       | \$291,658    | \$430,944    |
| Silver salts:                                                                                                                                                                                                                                |              |              |
| Ounces.                                                                                                                                                                                                                                      | 2,563,238    | 2,030,399    |
| Value.                                                                                                                                                                                                                                       | \$846,059    | \$727,428    |
| Platinum salts:                                                                                                                                                                                                                              |              |              |
| Ounces.                                                                                                                                                                                                                                      | 365          | 1,561        |
| Value.                                                                                                                                                                                                                                       | \$6,998      | \$19,123     |
| Thorium compounds, radium, uranium and vanadium.                                                                                                                                                                                             | \$1,388,477  |              |
| Vanillin.                                                                                                                                                                                                                                    |              |              |
| Pounds.                                                                                                                                                                                                                                      | 120,619      |              |
| Value.                                                                                                                                                                                                                                       | \$525,219    |              |
| Chemically pure (C. P.) preparations, including C. P. acids, alcohol, etc.                                                                                                                                                                   | \$530,476    |              |
| Chemicals used in the manufacture of photographic materials, not otherwise specified.                                                                                                                                                        | \$121,690    | \$4,790,370  |
| Other specified fine chemicals—Refined camphor, synthetic oils and perfumery bases, refined fusel oil, hypophosphites, ethyl chloride, sulphonic methane, and sulphonic-ethylmethane, nicotine, and butyric ether (named in order of value). | \$581,528    |              |
| All other fine chemicals, not reported separately.                                                                                                                                                                                           | \$912,780    |              |

## XII.—Chemicals, not otherwise specified.

|                           | 1914         | 1909         |
|---------------------------|--------------|--------------|
| Total value.              | \$47,597,084 | \$42,403,414 |
| Acetone:                  |              |              |
| Number of establishments. | 8            | 8            |
| Pounds.                   | 10,425,817   | 7,761,696    |
| Value.                    | \$1,099,585  | \$812,978    |

<sup>18</sup> For chlorine see "Bleaching materials."<sup>19</sup> Not including anhydrous ammonia produced at by-product recovery works (mainly ammoniacal liquor sold on a pound basis of NH<sub>3</sub> content) as follows: In 1914, 25,370,509 pounds; valued at \$2,300,137; in 1909, 4,871,014 pounds, valued at \$448,455.<sup>20</sup> Equivalent to 2,378,400 cubic feet at atmospheric pressure.<sup>21</sup> Quantity reported in pounds.<sup>22</sup> At atmospheric pressure.<sup>23</sup> In addition, alkalooids and derivatives valued at \$11,493,168 were reported by manufacturers of druggists' preparations and patent medicines.<sup>24</sup> Not including ether made and consumed in the explosive industry.

## XII.—Chemicals, Not Otherwise Specified (Continued)

|                                                                                                                          | 1914         | 1909         |
|--------------------------------------------------------------------------------------------------------------------------|--------------|--------------|
| Acetate of lime:                                                                                                         |              |              |
| Number of establishments.                                                                                                | 78           | 91           |
| Pounds.                                                                                                                  | 163,522,000  | 141,478,001  |
| Value.                                                                                                                   | \$2,138,909  | \$2,118,443  |
| Ammonium salts:                                                                                                          |              |              |
| Chloride—                                                                                                                |              |              |
| Pounds.                                                                                                                  | 11,511,934   | (1)          |
| Value.                                                                                                                   | \$641,040    |              |
| Sulphate—                                                                                                                |              |              |
| Pounds.                                                                                                                  | 8,846,616    | (1)          |
| Value.                                                                                                                   | \$211,314    |              |
| Other—Acetate, bifluoride, carbonate, phosphate, picrate, etc.                                                           | \$260,801    | (1)          |
| Ammonia: <sup>25</sup>                                                                                                   |              |              |
| Pounds.                                                                                                                  | 35,544,246   | 20,983,476   |
| Value.                                                                                                                   | \$1,412,236  | \$839,820    |
| Barium salts:                                                                                                            |              |              |
| Sulphate (blanc fixe)—                                                                                                   |              |              |
| Pounds.                                                                                                                  | 18,278,000   | 8,152,000    |
| Value.                                                                                                                   | \$257,415    | \$86,986     |
| Other—Carbonate, chloride, etc.                                                                                          | \$103,204    | (1)          |
| Copper salts:                                                                                                            |              |              |
| Sulphate (blue vitriol)—                                                                                                 |              |              |
| Pounds.                                                                                                                  | 37,152,351   | 36,546,553   |
| Value.                                                                                                                   | \$1,598,944  | \$1,531,574  |
| Other.                                                                                                                   | \$14,383     | (1)          |
| Cream of tartar:                                                                                                         |              |              |
| Number of establishments.                                                                                                | 8            | 5            |
| Pounds.                                                                                                                  | 12,646,120   | 15,592,937   |
| Value.                                                                                                                   | \$3,124,958  | \$2,925,883  |
| Epsom salts (magnesium sulphate):                                                                                        |              |              |
| Number of establishments.                                                                                                | 12           | 10           |
| Pounds.                                                                                                                  | 29,265,115   | 21,621,297   |
| Value.                                                                                                                   | \$246,999    | \$189,791    |
| Formaldehyde:                                                                                                            |              |              |
| Number of establishments.                                                                                                | 3            | 3            |
| Pounds.                                                                                                                  | 8,426,247    | 3,794,486    |
| Value.                                                                                                                   | \$655,174    | \$363,717    |
| Glycerine: <sup>26</sup>                                                                                                 |              |              |
| Crude, for sale—                                                                                                         |              |              |
| Pounds.                                                                                                                  | 16,568,920   |              |
| Value.                                                                                                                   | \$2,278,976  |              |
| Refined, pounds.                                                                                                         | 60,944,799   | 79,677,490   |
| For sale.                                                                                                                | 59,810,405   | \$11,752,580 |
| Value.                                                                                                                   | \$10,779,204 |              |
| Made and consumed, pounds                                                                                                | 1,134,394    | (1)          |
| Value.                                                                                                                   | \$1,134,394  |              |
| Iron salts:                                                                                                              |              |              |
| Sulphate (copperas)—                                                                                                     |              |              |
| Pounds.                                                                                                                  | 27,024,823   | 25,637,092   |
| Value.                                                                                                                   | \$552,772    | \$78,467     |
| Other salts and compounds—Iron liquor (ferrous acetate), chloride, nitrate, oxide, ferrotungsten, vanadate of iron, etc. |              |              |
| Value.                                                                                                                   | \$838,993    | (1)          |
| Lead salts:                                                                                                              |              |              |
| Arsenate—                                                                                                                |              |              |
| Number of establishments.                                                                                                | 11           |              |
| Pounds.                                                                                                                  | 8,641,856    | (1)          |
| Value.                                                                                                                   | \$511,688    |              |
| Other—                                                                                                                   |              |              |
| Pounds.                                                                                                                  | 7,290,936    | (1)          |
| Value.                                                                                                                   | \$474,450    |              |
| Mercurial salts:                                                                                                         |              |              |
| Pounds.                                                                                                                  | 605,701      | (1)          |
| Value.                                                                                                                   | \$518,023    |              |
| Nickel salts:                                                                                                            |              |              |
| Pounds.                                                                                                                  | 409,548      | (1)          |
| Value.                                                                                                                   | \$157,149    |              |
| Niter cake:                                                                                                              |              |              |
| Number of establishments.                                                                                                | 31           | 24           |
| Total production, tons.                                                                                                  | 46,143       |              |
| For sale.                                                                                                                | 24,129       | 27,546       |
| Value.                                                                                                                   | \$31,580     | \$53,693     |
| Made and consumed, tons.                                                                                                 | 22,014       | (1)          |
| Sulphur, refined:                                                                                                        |              |              |
| Tons.                                                                                                                    | 23,166       | 25,269       |
| Value.                                                                                                                   | \$1,141,000  | \$891,501    |
| Tin salts:                                                                                                               |              |              |
| Pounds.                                                                                                                  | 8,291,239    | 10,293,377   |
| Value.                                                                                                                   | \$2,028,511  | \$1,535,350  |
| Zinc salts:                                                                                                              |              |              |
| Pounds.                                                                                                                  | 40,786,886   | 25,054,213   |
| Value.                                                                                                                   | \$1,130,959  | \$472,302    |

## XII.—Chemicals, not otherwise specified—Con.

|                                           | 1914         | 1909         |
|-------------------------------------------|--------------|--------------|
| Other specified chemicals <sup>27</sup> . | \$3,055,314  |              |
| Unclassified chemicals.                   | \$12,483,523 | \$18,750,329 |

## XIII.—All other products

|                                           | 1914        | 1909        |
|-------------------------------------------|-------------|-------------|
| Chemical by-products and residues.        |             |             |
| Pyrite cinder.                            | \$399,458   | \$325,632   |
| All other.                                | \$4,010,162 | \$5,558,976 |
| By-products, not chemical.                | \$3,702,017 | \$2,209,078 |
| Amount received for custom work.          | \$888,734   |             |
| Includes citric and lactic acids in 1899. |             |             |

<sup>25</sup> Anhydrous ammonia reported under "Compressed or liquefied gases."<sup>26</sup> Figures not available for total production of crude glycerine, 1914, as that made and consumed in the manufacture of a large portion of the refined glycerine was not reported.<sup>27</sup> Produced by chemical plants, 19,206,084 pounds; by rolling mills, 13,158,859 pounds; by wire mills, 60,113,880 pounds.<sup>28</sup> In addition, 11,690,006 pounds of copperas were made and consumed in the same establishments.<sup>29</sup> Domestic production of sulphur, United States Geological Survey, 327,634 tons (2,240 pounds); imports for consumption, 26,135 tons.<sup>30</sup> Comprises: Acetanilid, acetone oil, acid calcium phosphate and calcium salts, aluminum chloride, antimony salts, arsenic (total production, as reported by the Geological Survey, 4,670 tons, valued at \$313,147), bismuth salts, cadmium salts, carbon bisulphide, cerium salts and alloys, chrome salts, crown filler, ether (not ethyl oxide), glyco-phosphates, hexamethylene-tetramine, iodine recombined and salts of iodine, iodoform, ketones, lithia and lithium salts, salts of magnesium and manganese, molybdenum, Paris green, sesquisulphate of phosphorus, strontium salts, sulphur chloride, titanium salts, trioxymethylene and tungsten



and other fillers are held in solid aggregations which may be molded or shaped. The value of the products reported includes the value of finished goods, such as combs, brushes, other toilet articles, collars and cuffs, buttons, talking-machine records etc. manufactured in the establishments making the plastic material, but does not include that of finished plastic goods made from purchased plastic stock.

The group of compressed or liquified gases (Group 10) embraces all gases which are compressed or liquified for sale, with the exception of illuminating gases (acetylene, Pintsch gas, Blau gas).

The group of fine chemicals (Group 11) embraces chemicals sold in the trade as chemically or absolutely pure; those which are more especially made use of in analytical operations and in pharmacy; and chemicals, like the salts of the precious metals, of a high unit value. The limitations of the group are not sharply defined, and as a result the statistics may not represent the total output of the respective products, since in some cases the data for certain products may have been included with those for unclassified goods, and, as reported at different censuses, may not be strictly comparable.

The figures in Table 108 aim to give the total production of each commodity in so far as the same is ascertainable from the returns, irrespective of whether it is a principal or subsidiary product of the establishment reporting, or the industry under which the establishment is classified. For example, the production of acetic acid, acetone, acetate of lime, and formaldehyde reported in this table includes that made in wood distillation establishments, the figures for which are given in Table 122; and the production of glycerin here reported, both crude and refined, includes the glycerine product of soap works as given in Table 120.

#### CLEANSING AND POLISHING PREPARATIONS

The products of the establishments in this industry include washing, ironing, sweeping, and scouring compounds; laundry and floor wax; pumice stone and tripoli; and especially preparations for cleansing and polishing furniture, floors, wall paper, gloves, metal ware, and cars, automobile body polish, paint and varnish removers, rust and stain removers etc. In Table 106 separate statistics are given for those establishments whose products of chief value were cleansing preparations, and for those making polishing preparations as their chief product.

In addition to the products covered by the table, cleaning preparations to the value of \$520,846 and polishing preparations to the value of \$1,121,178 were reported by establishments assigned to other classifications, principally those making mops, dusters etc. and those making soap.

Some cleansing and polishing preparations may have been reported under "all other products" by the large soap manufacturers and by the few slaughtering and meat-packing establishments where the soap departments were not returned as separate establishments. Washing soda (sal soda) is included under "chemicals."

#### COKE, NOT INCLUDING GAS-HOUSE COKE

The principal product of establishments under this classification is coke obtained by the distillation of coal in coke ovens. From the "by-product ovens" a number

of valuable by-products are obtained—tar, ammonium sulphate, and ammonia liquors. Establishments engaged primarily in the manufacture of gas, and making coke as a subsidiary product, are not included. Statistics of the materials and products for this industry are collected annually by the United States Geological Survey, therefore such data were not reported to the census in 1914. The following table gives the totals for that year as compiled by the United States Geological Survey, in comparison with those for the censuses of 1909, 1904, and 1899.

The total production of coke, including gas-house coke sold and that made and consumed in gas manufacture, was 138,000 tons in 1914 as compared with 41,947,000 in 1909 and 27,857,000 in 1904.

TABLE 120

## SOAP

|                                                     | 1914          | 1909          |
|-----------------------------------------------------|---------------|---------------|
| Number of establishments.....                       | 513           | 526           |
| Soap industry.....                                  | 371           | 420           |
| Manufacturing subsidiary soap products.....         | 142           | 106           |
| <b>Materials<sup>1</sup></b>                        |               |               |
| Total cost.....                                     | \$88,866,786  | \$72,179,418  |
| Tallow, grease and other fats:                      |               |               |
| Pounds.....                                         | 546,289,571   | 413,969,787   |
| Cost.....                                           | \$32,365,899  | \$23,341,905  |
| Cocoon and palm-kernel oil:                         |               |               |
| Gallons.....                                        | 13,225,337    | 11,856,337    |
| Cost.....                                           | \$9,406,583   | \$5,875,294   |
| Cottonseed oil:                                     |               |               |
| Consumption, gallons.....                           | 16,144,786    | 26,611,810    |
| Purchased:                                          |               |               |
| Gallons.....                                        | 15,993,691    | 24,221,712    |
| Cost.....                                           | \$6,700,688   | \$9,718,908   |
| Produced and consumed, gallons.....                 | 241,095       | 2,390,098     |
| Roach:                                              |               |               |
| Pounds.....                                         | 185,310,786   | 207,296,447   |
| Cost.....                                           | \$4,067,992   | \$4,362,412   |
| Feet:                                               |               |               |
| Pounds.....                                         | 123,032,886   | 94,010,892    |
| Cost.....                                           | \$6,456,784   | \$2,453,609   |
| Caustic soda:                                       |               |               |
| Tons (2,000 pounds).....                            | 55,320        | 52,172        |
| Cost.....                                           | \$1,936,575   | \$2,212,232   |
| Soda ash:                                           |               |               |
| Tons (2,000 pounds).....                            | 104,983       | 121,016       |
| Cost.....                                           | \$1,997,575   | \$2,281,787   |
| Other materials.....                                | \$25,734,690  | \$21,933,191  |
| <i>Produced in works where consumed<sup>2</sup></i> |               |               |
| Red oil, gallons.....                               | 3,653,557     | 3,128,736     |
| Tallow, pounds.....                                 | 5,331,000     | 16,664,000    |
| Cottonseed oil, gallons.....                        | 241,095       | 2,390,098     |
| Caustic lye (30° Baumé), gallons.....               | 22,777,000    | 15,804,000    |
| Sodium silicate, pounds.....                        | 43,197,255    | 37,466,246    |
| Glycerine, pounds.....                              | 2,156,591     | 5,879,279     |
| Framed soap, pounds.....                            | 618,096,000   | 524,775,000   |
| <b>Products</b>                                     |               |               |
| Total value.....                                    | \$135,304,499 | \$115,455,190 |
| Soap industry.....                                  | \$127,942,441 | \$111,352,727 |
| Subsidiary products, other industries.....          | \$7,362,058   | \$4,092,413   |
| <b>Hard soaps:</b>                                  |               |               |
| Quantity, pounds.....                               | 2,064,225,000 | 1,794,249,000 |
| Tallow soap.....                                    | 938,447,000   | 944,409,000   |
| Olefin soap.....                                    | 42,524,000    | 33,696,000    |
| Feet soap.....                                      | 111,063,000   | 73,444,000    |
| Toilet soap.....                                    | 169,926,000   | 111,371,000   |
| Powdered soap.....                                  | 367,744,000   | 361,176,000   |
| Soap chips.....                                     | 97,746,000    | 329,953,000   |
| All other hard soaps.....                           | 336,778,000   | 901,064,466   |
| Value.....                                          | \$104,464,542 | \$91,064,466  |
| <b>Soft soap:</b>                                   |               |               |
| Pounds.....                                         | 57,002,000    | 60,037,000    |
| Value.....                                          | \$1,697,424   | \$1,269,187   |
| Special soap articles.....                          | \$832,654     | \$706,177     |
| <b>Glycerine<sup>3</sup></b>                        |               |               |
| Crude, for sale.....                                | 12,745,336    |               |
| Value.....                                          | \$1,817,536   |               |
| Refined, pounds.....                                | 34,831,082    |               |
| For sale.....                                       |               | \$6,790,282   |
| Value.....                                          | \$2,674,491   |               |
| Produced and consumed, pounds.....                  | 5,775,887     |               |
| Value.....                                          | 2,156,591     | 5,879,279     |
| <b>Lye:</b>                                         |               |               |
| Pounds.....                                         | 23,346,000    |               |
| Value.....                                          | \$891,265     |               |
| Perfumes and toilet preparations.....               | \$6,804,508   | \$15,625,078  |
| Candles.....                                        | \$150,492     |               |
| All other products.....                             | \$12,870,191  |               |

<sup>1</sup> Not including those consumed in soap manufacture in establishments making subsidiary soap products.

<sup>2</sup> See table 106, chemicals, for total glycerine production.

<sup>3</sup> Includes cottonseed products, \$3,008,386; chemicals, \$941,379; cleansing and polishing preparations, \$500,466; grease and tallow, \$235,195; hard oil, \$125,706; glycerine and extracts, \$73,003; patent medicines and compounds, \$64,477; and miscellaneous and undesignated products, \$7,921,579.

## DRUG GRINDING

Powdered or pulverized drugs are the principal products reported by establishments under this classification, and include the grinding of drugs, charcoal, roots, herbs, gums, licorice roots etc.

TABLE III

## DYE STUFFS AND EXTRACTS

|                                                                                                                                       | 1914         | 1909         |
|---------------------------------------------------------------------------------------------------------------------------------------|--------------|--------------|
| Number of establishments.....                                                                                                         | 133          | 124          |
| Dyestuff and extract industry.....                                                                                                    | 112          | 107          |
| Establishments manufacturing dyestuffs and extracts as subsidiary products.....                                                       | 21           | 17           |
| Products                                                                                                                              |              |              |
| Total value.....                                                                                                                      | \$21,382,689 | \$16,788,676 |
| Dyestuff and extract industry.....                                                                                                    | \$20,620,336 | \$15,954,574 |
| Subsidiary products from other industries.....                                                                                        | \$762,353    | \$834,102    |
| Dyestuffs.....                                                                                                                        | \$7,114,855  | \$4,819,247  |
| Natural dyestuffs.....                                                                                                                | \$1,862,162  | \$1,135,694  |
| Dyedwood extracts—                                                                                                                    |              |              |
| Logwood—                                                                                                                              |              |              |
| Number of establishments.....                                                                                                         | 9            | (1)          |
| Pounds.....                                                                                                                           | 28,989,962   | 22,317,248   |
| Value.....                                                                                                                            | \$1,311,966  | \$991,974    |
| Fustic—                                                                                                                               |              |              |
| Number of establishments.....                                                                                                         | 5            | (1)          |
| Pounds.....                                                                                                                           | 4,509,943    | (1)          |
| Value.....                                                                                                                            | \$222,804    | (1)          |
| Quercitron—                                                                                                                           |              |              |
| Number of establishments.....                                                                                                         | 4            | (1)          |
| Pounds.....                                                                                                                           | 3,844,882    | (1)          |
| Value.....                                                                                                                            | \$112,945    | (1)          |
| Other dyewood extracts, Brazilwood, cutch, etc.—                                                                                      |              |              |
| Pounds.....                                                                                                                           | 3,434,150    | (1)          |
| Value.....                                                                                                                            | \$90,934     | (1)          |
| Dyewoods, ground or chipped—logwood, fustic, Brazilwood, turmeric, etc.—                                                              |              |              |
| Pounds.....                                                                                                                           | 4,128,202    | 15,046,954   |
| Value.....                                                                                                                            | \$45,647     | \$143,720    |
| Dyestuffs, not dyewoods—ground and extracts.....                                                                                      | \$77,866     | (1)          |
| Artificial dyestuff:                                                                                                                  |              |              |
| Synthetic or coal-tar dyes, including intermediates and products resulting from the blending of imported colors—                      |              |              |
| Number of establishments.....                                                                                                         | 16           |              |
| Pounds.....                                                                                                                           | 12,169,635   |              |
| Value.....                                                                                                                            | \$4,652,947  | 12,758,774   |
| Mineral colors or dyes, such as chrome yellow, orange or green, iron buff, prussian blue, ultramarine, etc.—                          |              |              |
| Number of establishments.....                                                                                                         | 14           |              |
| Pounds.....                                                                                                                           | 4,991,336    |              |
| Value.....                                                                                                                            | \$599,746    | \$3,683,553  |
| Tanning materials.....                                                                                                                | \$7,898,672  | \$7,123,971  |
| Extracts—                                                                                                                             |              |              |
| Oak—                                                                                                                                  |              |              |
| Pounds.....                                                                                                                           | 8,797,218    |              |
| Value.....                                                                                                                            | \$192,844    | 292,400,285  |
| Chestnut—                                                                                                                             |              |              |
| Pounds.....                                                                                                                           | 319,639,906  | \$6,132,592  |
| Value.....                                                                                                                            | \$3,952,806  |              |
| Hemlock—                                                                                                                              |              |              |
| Pounds.....                                                                                                                           | 18,978,013   | 12,588,078   |
| Value.....                                                                                                                            | \$340,402    | \$280,487    |
| Sumac—                                                                                                                                |              |              |
| Pounds.....                                                                                                                           | 4,512,361    | 3,148,790    |
| Value.....                                                                                                                            | \$129,631    | \$107,456    |
| Quebracho, chronic tanning, spruce, myrobalans, gambier, mangrove or palmetto, and gallnuts extracts, in the order named as to value— |              |              |
| Pounds.....                                                                                                                           | 99,799,418   |              |
| Value.....                                                                                                                            | \$2,944,906  | \$603,436    |
| Other tanning materials.....                                                                                                          | \$338,083    |              |
| Mordants:                                                                                                                             |              |              |
| Tannic acid.....                                                                                                                      | 760,100      |              |
| Pounds.....                                                                                                                           | \$234,630    | \$628,798    |
| Other.....                                                                                                                            | \$157,791    |              |
| Assistants:                                                                                                                           |              |              |
| Turkey red oil—                                                                                                                       |              |              |
| Pounds.....                                                                                                                           | 11,681,884   | 1,814,506    |
| Other.....                                                                                                                            | \$820,491    | \$108,292    |
| Value.....                                                                                                                            | \$716,510    | (1)          |
| Sizes:                                                                                                                                |              |              |
| Dextrins—                                                                                                                             |              |              |
| Pounds.....                                                                                                                           | 18,913,641   |              |
| Value.....                                                                                                                            | \$705,584    | 16,148,931   |
| Gums, other than resin—                                                                                                               |              |              |
| Pounds.....                                                                                                                           | 3,832,182    | \$610,999    |
| Value.....                                                                                                                            | \$205,282    |              |
| Rosin.....                                                                                                                            |              |              |
| Pounds.....                                                                                                                           | 20,717,148   |              |
| Value.....                                                                                                                            | \$373,218    | \$1,835,046  |
| Other sizes.....                                                                                                                      | \$1,768,727  |              |
| All other products.....                                                                                                               | \$1,386,879  | \$1,662,323  |

\* Figures not available

There are no statistics giving the quantity or value of drugs ground by establishments classed under "patent medicines and compounds," and "druggists' preparations."

## DRUGGISTS' PREPARATIONS, PATENT AND PROPRIETARY MEDICINES AND COMPOUNDS, AND PERFUMERY AND COSMETICS

*Druggists' Preparations.*—This industry includes all materials for use by druggists in compounding medicines to be dispensed upon physicians' prescriptions or orders. These comprise tinctures, fluid extracts, medicinal sirups, and other liquid preparations; pills, tablets, powders etc.; alkaloids and derivatives (cocaine, codein, morphine, quinine, and strychnine); synthetic medicinal preparations, such as acetanilid, acetphenetidin, phenolphthalein, saccharin, methylsalicylate etc.; medicinal metals and their salts (bromides, acetates, citrates, bismuth etc.); and biological products, such as serums, vaccines, toxins etc. Concerns engaged in drug grinding as their principal business are not included in this industry.

*Patent medicines and compounds.*—This industry consists of "patent and proprietary medicines" which are those sold under the protection of a patent, copyright, or trade-mark, or prepared according to a secret formula; and "patent and proprietary compounds" which include all such compounds not intended for medical use, such as fire-extinguisher compounds, household ammonia, insecticides etc.

*Perfumery and cosmetics.*—This industry comprises cologne, toilet waters, face powders, cold cream etc. and perfumes.

## DYE STUFFS AND EXTRACTS

Establishments in this industry make materials for dyeing and tanning purposes. The products include natural dyestuffs made from wood, bark, or berries; dyeing extracts; artificial dyestuffs, including synthetic or coal-tar dyes and the mineral colors or dyes; tanning extracts and liquors, including chrome tanning solutions; and mordants, assistants, and sizes. The statistics for dyestuffs and extracts given in the table cover the products of establishments manufacturing the same for sale and do not include those made by dye and print works or tanneries and consumed by the same in further processes of manufacture.

Detail statistics of the quantity and value of the products for the censuses from 1899 to 1914, are given in Table III.

## EXPLOSIVES

Establishments included in this classification manufacture blasting powder, black gunpowder, nitroglycerin, dynamite, including all explosives containing nitroglycerine, permissible explosives, guncotton, including pyroxylin, and all other cellulose nitrates; smokeless powder; and all other high-powered powders used as propellants. Table 112 gives detail statistics for materials and products, for the census of 1914, in comparison with 1909.

## FERTILIZERS

Establishments included in this classification manufacture principally "complete fertilizers" by which is meant a mixture of superphosphates with both potash

and ammoniates; ammoniated fertilizers; superphosphates from minerals, bones etc.; concentrated phosphates etc. The production, for sale, of sulphuric and other acids, fish scrap, soda products, oil, bone black, glue, grease, and various chemicals is also reported. Large quantities of some of these products are made by fertilizer establishments for their own use.

The quantity and value of the different classes of fertilizers manufactured in 1914 in comparison with those

for the censuses of 1909, are given in Table 113. The statistics include the fertilizer products of establishments engaged primarily in the manufacture of products other than fertilizers, chief of which are slaughtering and meat-packing establishments and cottonseed oil mills.

The value of all products of the industry proper, which includes some that are not fertilizers, was \$153,196,152 in 1914, as compared with \$103,960,213 in 1909. Including the fertilizer by-products of other industries, the total production of fertilizers in 1914 was 8,432,206 net tons, valued at \$153,260,212. During the period 1909-1914 the tonnage of the fertilizer products increased 50.1 per cent. Some of the materials, such as sulphuric acid and superphosphates, are the products of establishments engaged in this industry, and therefore are duplicated in the total value of products.

#### GAS, ILLUMINATING AND HEATING

Establishments under this classification manufacture illuminating and fuel gas, chiefly by destructive distillation of coal, wood, resins, and oil, or other carbonaceous substances. The production of natural gas, of course, is not included. Many manufacturing concerns convert coal, through imperfect combustion, into "producer" gas for use as fuel or in gas engines. This process, however, is not covered by the statistics of the gas industry, nor is the production of blast-furnace gas. The manufacture of Pintsch gas, used principally for lighting railway cars, which carry it in compressed form, is included, likewise Blau gas and acetylene, whether distributed through mains or marketed compressed in cylinders, as well as the operations of municipal gas plants.

The statistics for the industry do not include those for establishments operating retort coke ovens, for which see Table 109. The gas purchased by the gas companies is largely retort coke-oven gas.

| Materials.                                         | 1914          | 1909             |
|----------------------------------------------------|---------------|------------------|
| Total cost                                         | \$25,626,539  | \$22,811,548     |
| Sulphur or brimstone . . . . .                     |               |                  |
| Tons . . . . .                                     | 15,832        | 17,389           |
| Cost . . . . .                                     | \$372,763     | \$367,866        |
| Powders . . . . .                                  |               |                  |
| Tons . . . . .                                     | 25,885        | ( <sup>1</sup> ) |
| Cost . . . . .                                     | \$139,496     | ( <sup>1</sup> ) |
| Nitrate of soda . . . . .                          |               |                  |
| Tons . . . . .                                     | 190,960       | 188,889          |
| Cost . . . . .                                     | \$8,979,877   | \$7,892,336      |
| Glycerine . . . . .                                |               |                  |
| Pounds . . . . .                                   | 29,002,008    | ( <sup>1</sup> ) |
| Cost . . . . .                                     | \$5,439,405   | ( <sup>1</sup> ) |
| Acids . . . . .                                    |               |                  |
| Sulphuric—                                         |               |                  |
| Consumption, tons . . . . .                        | 83,605        | 65,066           |
| Purchased—                                         |               |                  |
| Tons . . . . .                                     | 52,398        | 22,501           |
| Cost . . . . .                                     | \$723,795     | \$406,204        |
| Produced in works where consumed, tons . . . . .   | 31,207        | 42,555           |
| Nitric—                                            |               |                  |
| Consumption, pounds . . . . .                      | 102,920,184   | 70,559,756       |
| Purchased—                                         |               |                  |
| Pounds . . . . .                                   | 8,694,684     | 7,591,756        |
| Cost . . . . .                                     | \$476,404     | \$541,314        |
| Produced in works where consumed, pounds . . . . . | 94,226,000    | 62,968,000       |
| Mixed—                                             |               |                  |
| Consumption, pounds . . . . .                      | 177,306,992   | ( <sup>1</sup> ) |
| Purchased—                                         |               |                  |
| Pounds . . . . .                                   | 38,509,594    | 51,764,694       |
| Cost . . . . .                                     | \$1,047,377   | \$1,512,626      |
| Produced in works where consumed, pounds . . . . . | 138,797,398   | ( <sup>1</sup> ) |
| Produced in works where consumed . . . . .         | \$8,447,422   | \$12,091,202     |
| All other materials . . . . .                      |               |                  |
| Produced in works where consumed . . . . .         |               |                  |
| Acids . . . . .                                    |               |                  |
| Sulphuric, tons . . . . .                          | 31,207        | 42,555           |
| 50° Baume . . . . .                                | 23,596        | ( <sup>1</sup> ) |
| 66° Baume . . . . .                                | 7,611         | ( <sup>1</sup> ) |
| Nitric, pounds . . . . .                           | 94,226,000    | 62,968,000       |
| Mixed, pounds . . . . .                            | 138,797,398   | ( <sup>1</sup> ) |
| Saltpetre, pounds . . . . .                        | 5,409,350     | 12,050,225       |
| Nitroglycerine, pounds . . . . .                   | 61,517,400    | 70,289,667       |
| Nitrate of ammonia, pounds . . . . .               | 29,491,837    | 10,904,319       |
| Cellulose nitrates, pounds . . . . .               | 3,616,895     | 5,000,226        |
| Charcoal, bushels . . . . .                        | 139,508       | 737,884          |
| Total value . . . . .                              | \$41,432,970  | \$40,139,661     |
| Products . . . . .                                 |               |                  |
| Explosives, total . . . . .                        | \$481,752,040 | \$487,481,152    |
| Pounds . . . . .                                   | \$39,645,382  | \$37,983,868     |
| Dynamite . . . . .                                 | 26            | 26               |
| Number of establishments . . . . .                 | 223,667,630   | 220,145,791      |
| Pounds . . . . .                                   | \$20,553,633  | \$20,998,820     |
| Permissible explosives . . . . .                   | 20            | 13               |
| Number of establishments . . . . .                 | 18,113,601    | 9,607,448        |
| Pounds . . . . .                                   | \$1,604,072   | \$863,209        |
| Nitroglycerine . . . . .                           | 58            | 49               |
| Number of establishments . . . . .                 | 32            | 23               |
| For sale as such . . . . .                         | 27            | 26               |
| For consumption . . . . .                          | 65,302,883    | 74,212,980       |
| Production, pounds . . . . .                       | 3,785,474     | 3,923,313        |
| Sold as such . . . . .                             | 1,047,377     | \$863,360        |
| Pounds . . . . .                                   | \$950,611     | \$863,360        |
| Consumed in works where produced, pounds . . . . . | 61,517,400    | 70,289,667       |
| Blasting powder . . . . .                          | 48            | 38               |
| Number of establishments . . . . .                 | 207,423,675   | 233,477,175      |
| Pounds . . . . .                                   | \$8,459,113   | \$9,608,265      |
| Gunpowder, black—                                  |               |                  |
| Number of establishments . . . . .                 | 7,685,036     | 12,862,700       |
| Pounds . . . . .                                   | \$977,455     | \$1,736,427      |
| Other explosives—                                  |               |                  |
| Number of establishments . . . . .                 | 4             | 2                |
| Guncotton or pyroxilin . . . . .                   | 5             | 4                |
| Smokeless powder . . . . .                         | 6             | 8                |
| Other . . . . .                                    | 21,076,624    | 7,464,725        |
| Pounds . . . . .                                   | \$7,100,478   | \$3,913,787      |
| Value . . . . .                                    | \$1,787,588   | \$2,155,793      |
| All other products . . . . .                       |               |                  |

|                                                            | 1914          | 1909             |
|------------------------------------------------------------|---------------|------------------|
| Number of establishments . . . . .                         | 1,238         | 843              |
| Fertilizer industry . . . . .                              | 784           | 550              |
| Manufacturing fertilizers as subsidiary products . . . . . | 454           | 293              |
| Materials . . . . .                                        |               |                  |
| Total cost . . . . .                                       | \$119,222,003 | \$73,165,544     |
| The fertilizer industry . . . . .                          | \$107,954,644 | \$69,521,920     |
| Other industries, fertilizer products . . . . .            | \$11,267,359  | \$3,643,624      |
| Ammoniates . . . . .                                       |               |                  |
| Tons . . . . .                                             | 1,213,168     | 842,557          |
| Cost . . . . .                                             | \$28,550,524  | \$17,200,611     |
| Cottonseed meal—                                           |               |                  |
| Tons . . . . .                                             | 325,234       |                  |
| Cost . . . . .                                             | \$8,419,383   |                  |
| Tankage and ammoniates, not elsewhere specified—           |               |                  |
| Tons . . . . .                                             | 887,934       | 842,557          |
| Cost . . . . .                                             | \$20,313,141  | \$17,200,611     |
| Ammonium sulphate . . . . .                                |               |                  |
| Tons . . . . .                                             | 149,924       | 65,592           |
| Cost . . . . .                                             | \$9,015,163   | \$3,732,112      |
| Cyanamid or lime nitrogen . . . . .                        |               |                  |
| Tons . . . . .                                             | 25,911        | ( <sup>2</sup> ) |
| Cost . . . . .                                             | \$1,176,119   | ( <sup>2</sup> ) |
| Nitrate of soda . . . . .                                  |               |                  |
| Tons . . . . .                                             | 162,184       | 89,846           |
| Cost . . . . .                                             | \$7,511,809   | \$3,916,320      |
| For mixed fertilizers—                                     |               |                  |
| Tons . . . . .                                             | 147,050       | ( <sup>2</sup> ) |
| Cost . . . . .                                             | \$6,807,228   | ( <sup>2</sup> ) |
| For acid manufacture—                                      |               |                  |
| Tons . . . . .                                             | 15,134        | ( <sup>2</sup> ) |
| Cost . . . . .                                             | \$704,561     | ( <sup>2</sup> ) |
| Phosphate rock . . . . .                                   |               |                  |
| Tons . . . . .                                             | 2,080,961     | 1,549,497        |
| Cost . . . . .                                             | \$11,222,992  | \$8,826,834      |
| Fish . . . . .                                             |               |                  |
| Tons . . . . .                                             | 250,110       | 242,045          |
| Cost . . . . .                                             | \$3,111,991   | \$3,066,613      |
| Raw bones . . . . .                                        |               |                  |
| Tons . . . . .                                             | 64,590        | ( <sup>2</sup> ) |
| Cost . . . . .                                             | \$1,603,353   | ( <sup>2</sup> ) |

<sup>1</sup> Figures not available.

<sup>2</sup> In addition 5,072,387 pounds, to the value of \$1,632,335, were made by Federal establishments, comprising 4,998,537 pounds of smokeless powder and 73,850 pounds of other explosives.

<sup>3</sup> In addition 1,471,042 pounds, to the value of \$656,959 were made by Federal establishments and 219,356 pounds to the value of \$155,979 by establishments engaged primarily in the manufacture of products other than explosives.



TABLE 113—Continued

| FERTILIZERS (TONS OF 2,000 POUNDS)                  |               |                  |      |
|-----------------------------------------------------|---------------|------------------|------|
| Materials—Continued                                 |               | 1914             | 1909 |
| Steamed bone:                                       |               |                  |      |
| Tons                                                | 55,067        | ( <sup>2</sup> ) |      |
| Cost                                                | \$1,178,959   | ( <sup>2</sup> ) |      |
| Ground bone:                                        |               |                  |      |
| Tons                                                | 25,139        | ( <sup>2</sup> ) |      |
| Cost                                                | \$593,226     | ( <sup>2</sup> ) |      |
| Bone discard:                                       |               |                  |      |
| Tons                                                | 3,395         | ( <sup>2</sup> ) |      |
| Cost                                                | \$35,007      | ( <sup>2</sup> ) |      |
| Pyrites:                                            |               |                  |      |
| Tons                                                | 613,842       | 456,574          |      |
| Cost                                                | \$3,590,235   | \$2,831,994      |      |
| Sulphur or brimstone:                               |               |                  |      |
| Tons                                                | 2,041         | 4,236            |      |
| Cost                                                | \$42,716      | \$68,924         |      |
| Sulphuric acid:                                     |               |                  |      |
| Purchased—                                          |               |                  |      |
| Tons                                                | 728,889       | 620,708          |      |
| Cost                                                | \$4,387,317   | \$3,460,132      |      |
| Made and consumed, tons                             | 1,276,715     | 841,935          |      |
| Superphosphate:                                     |               |                  |      |
| Purchased—                                          |               |                  |      |
| Tons                                                | 1,096,178     | 532,886          |      |
| Cost                                                | \$9,301,501   | \$5,175,957      |      |
| Made and consumed (acid phosphate), tons            | 2,723,317     | 1,858,865        |      |
| Basic slag or Thomas phosphate powder:              |               |                  |      |
| Tons                                                | 16,190        | ( <sup>2</sup> ) |      |
| Cost                                                | \$144,213     | ( <sup>2</sup> ) |      |
| Gypsum:                                             |               |                  |      |
| Tons                                                | 120,128       | ( <sup>2</sup> ) |      |
| Cost                                                | \$445,416     | ( <sup>2</sup> ) |      |
| Kalmit:                                             |               |                  |      |
| Tons                                                | 448,885       | 347,104          |      |
| Cost                                                | \$3,939,263   | \$3,008,183      |      |
| Potash salts:                                       |               |                  |      |
| Tons                                                | 529,973       | 270,450          |      |
| Cost                                                | \$12,774,113  | \$7,714,367      |      |
| Muriate of potash:                                  |               |                  |      |
| Tons                                                | 177,372       | ( <sup>2</sup> ) |      |
| Cost                                                | \$6,497,364   | ( <sup>2</sup> ) |      |
| Sulphate of potash:                                 |               |                  |      |
| Tons                                                | 39,232        | ( <sup>2</sup> ) |      |
| Cost                                                | \$1,684,998   | ( <sup>2</sup> ) |      |
| Double manure salts:                                |               |                  |      |
| Tons                                                | 108,580       | ( <sup>2</sup> ) |      |
| Cost                                                | \$1,740,241   | ( <sup>2</sup> ) |      |
| Nitrate of potash or saltpeter—                     |               |                  |      |
| Tons                                                | 507           | ( <sup>2</sup> ) |      |
| Cost                                                | \$28,287      | ( <sup>2</sup> ) |      |
| Other potash salts—                                 |               |                  |      |
| Tons                                                | 204,282       | ( <sup>2</sup> ) |      |
| Cost                                                | \$2,623,223   | ( <sup>2</sup> ) |      |
| Hardwood ashes:                                     |               |                  |      |
| Tons                                                | 4,437         | ( <sup>2</sup> ) |      |
| Cost                                                | \$54,171      | ( <sup>2</sup> ) |      |
| All other materials                                 | \$20,543,915  | \$14,161,497     |      |
| Products                                            |               |                  |      |
| Total value                                         | \$169,017,550 | \$111,871,481    |      |
| Fertilizer industry                                 | \$153,196,152 | \$103,960,213    |      |
| Supplementary fertilizer products, other industries | \$15,821,398  | \$7,911,268      |      |
| Fertilizers:                                        |               |                  |      |
| Tons                                                | 8,432,206     | 5,618,234        |      |
| Value                                               | \$153,260,212 | \$100,089,971    |      |
| Complete and ammoniated fertilizers*                |               |                  |      |
| Tons                                                | 5,612,421     | 3,523,759        |      |
| Value                                               | \$121,676,386 | \$74,109,507     |      |
| Superphosphates—                                    |               |                  |      |
| Production, tons                                    | 4,416,022     | 3,062,834        |      |
| For sale                                            | 1,692,705     | 1,223,969        |      |
| Made and consumed, tons                             | \$14,778,654  | \$15,744,831     |      |
| Concentrated phosphate—                             |               |                  |      |
| Tons                                                | 67,585        | 270,128          |      |
| Value                                               | \$1,367,005   | \$2,713,513      |      |
| Other fertilizers—                                  |               |                  |      |
| Tons                                                | 1,059,495     | 600,378          |      |
| Value                                               | \$15,438,167  | \$9,522,320      |      |
| Sulphuric acid (reduced to 50° Baume):              |               |                  |      |
| Production, tons                                    | 1,405,768     | 995,384          |      |
| For sale                                            | 129,053       | 153,449          |      |
| Made and consumed, tons                             | \$768,873     | \$928,582        |      |
| Fish scrap:                                         |               |                  |      |
| Tons                                                | 62,930        | 78,484           |      |
| Value                                               | \$1,915,530   | \$2,006,724      |      |
| Pyrite cinder:                                      |               |                  |      |
| Tons                                                | 245,082       | 291,653          |      |
| Value                                               | \$231,869     | \$143,607        |      |
| Oil:                                                |               |                  |      |
| Gallons                                             | 2,445,026     | 3,218,393        |      |
| Value                                               | \$778,337     | \$810,938        |      |
| Bone slack:                                         |               |                  |      |
| Pounds                                              | 41,054,769    | ( <sup>2</sup> ) |      |
| Value                                               | \$1,413,166   | ( <sup>2</sup> ) |      |
| Glue                                                | \$1,131,243   | ( <sup>2</sup> ) |      |
| Grease                                              | \$1,209,334   | ( <sup>2</sup> ) |      |
| All other products                                  | \$8,308,986   | \$7,891,659      |      |

The total production of gas made for sale by all establishments, inclusive of retort coke-ovens and the by-products of establishments outside of the gas and the coke industries, was, in 1914, 265,060,574 thousand

TABLE 109

| COKE (TONS OF 2,000 POUNDS)                             |               |                   |                   |
|---------------------------------------------------------|---------------|-------------------|-------------------|
| Coal                                                    |               | 1914 <sup>1</sup> | 1909 <sup>1</sup> |
| Coal charged into ovens:                                |               |                   |                   |
| Tons                                                    | 51,623,750    | 59,354,937        |                   |
| Cost                                                    | \$74,499,363  | \$62,203,382      |                   |
| Run of mine, tons—                                      |               |                   |                   |
| Unwashed                                                | 36,517,276    | 40,594,842        |                   |
| Washed                                                  | 5,515,290     | 6,007,760         |                   |
| Slack, tons—                                            |               |                   |                   |
| Unwashed                                                | 4,289,870     | 6,926,484         |                   |
| Washed                                                  | 5,301,314     | 5,825,851         |                   |
| Products                                                |               |                   |                   |
| Total value                                             | \$105,863,305 | \$98,078,383      |                   |
| Coke <sup>2</sup>                                       |               |                   |                   |
| Tons                                                    | 34,555,014    | 39,315,065        |                   |
| Value                                                   | \$88,334,217  | \$89,965,483      |                   |
| Made in beehive ovens—                                  |               |                   |                   |
| Tons                                                    | 23,335,971    | 33,060,421        |                   |
| Value                                                   | \$50,254,050  | \$69,530,794      |                   |
| Made in retort or by-product ovens—                     |               |                   |                   |
| Tons                                                    | 11,219,943    | 6,254,644         |                   |
| Value                                                   | \$38,080,167  | \$20,434,689      |                   |
| By-products obtained from retort or by-product ovens:   |               |                   |                   |
| Gas—                                                    |               |                   |                   |
| Cubic feet (thousands)                                  | 61,364,375    | 15,791,220        |                   |
| Value                                                   | \$6,009,583   | \$2,609,211       |                   |
| Tar—                                                    |               |                   |                   |
| Gallons                                                 | 109,901,315   | 60,126,006        |                   |
| Value                                                   | \$2,867,274   | \$1,408,611       |                   |
| Ammonia, sulphate or reduced to equivalent in sulphate— |               |                   |                   |
| Pounds                                                  | 170,763,906   | 123,111,197       |                   |
| Value                                                   | \$4,696,590   | \$3,227,316       |                   |
| Anhydrous ammonia—                                      |               |                   |                   |
| Pounds                                                  | 25,370,509    | 4,871,014         |                   |
| Value                                                   | \$2,300,137   | \$448,455         |                   |
| Ammonia liquor—                                         |               |                   |                   |
| Gallons                                                 | 5,938,233     | ( <sup>2</sup> )  |                   |
| Value                                                   | \$658,497     | ( <sup>2</sup> )  |                   |
| All other value                                         | \$997,007     | \$419,307         |                   |
| Equipment                                               |               |                   |                   |
| Ovens, number in existence at end of year               | 99,755        | 103,982           |                   |
| Building at end of year                                 | 1,249         | 2,950             |                   |
| Abandoned during the year                               | 3,675         | 201               |                   |

<sup>1</sup> Includes coal and coking products produced by establishments engaged primarily in the manufacture of products other than those covered by the industry designation.

<sup>2</sup> Not including gas-house coke, the statistics for which will be found under the classification "Gas, illuminating and heating."

<sup>3</sup> Mainly ammoniated liquor sold on pound basis of NH<sub>3</sub>.

<sup>4</sup> Reported to part as anhydrous ammonia and in part as ammonium sulphate or reduced equivalents.

<sup>5</sup> Mainly benzol.

cubic feet, valued at \$181,207,482, and in 1909, 166,667,641 thousand cubic feet, valued at \$141,478,557.

The statistics for materials and products for 1914, in comparison with those for 1909, are given in Table 114.

#### GLUE NOT ELSEWHERE SPECIFIED

The principal products of establishments included in this classification are glue, flexible and liquid; gelatin; and glue jelly or paste, derived from hides, bones, fleshings, and fish.

In addition to the products covered by Table 106 glue and gelatin to the value of \$3,088,764 were made in slaughtering and meat-packing establishments, while fertilizer factories reported glue to the value of \$1,131,243. Other establishments, principally those making sand and emery paper and cloth, tallow, soap stock, food preparations, oleo oil and fish oil, reported glue and gelatine to the value of \$1,772,872, making the total manufacture of glue \$19,725,703 in 1914, as compared with \$16,328,579 in 1909.

#### GREASE AND TALLOW, NOT INCLUDING LUBRICATING GREASES

Establishments in this classification render soap grease from fat, bones, meat, scraps, garbage etc., and render tallow from the solid fat of cattle, sheep, and

<sup>1</sup> Includes 179 cottonseed-oil mills, 64 grease and tallow establishments, 45 slaughtering and meat packing, and 166 distributed among some 15 other industries that produce wastes of fertilizing value.

<sup>2</sup> Figures not available.

<sup>3</sup> Includes 17,430 tons reported simply as potash salts.

<sup>4</sup> Includes fertilizers reported as ammoniated fertilizers but containing both superphosphates and potash, viz., in 1914, 1,519,156 tons; 1909, 522,389 tons; 1904, 775,967 tons; and 1899, 142,898 tons.

<sup>5</sup> Not including 155,634 tons in 1914, and 72,402 tons in 1909, of no value at the works.

<sup>6</sup> Includes chemicals—soda products, acids, etc.—to the value of \$400,597.

other animals. Establishments making grease and tallow reported hides, skins, bones, tankage, fertilizers, poultry feed, dried blood, oils, stearine, cracklings, hoofs, horns, glue stock, ground bones etc.

Table 106 gives separate statistics for those establishments making soap stock, for those rendering tallow, and for those reporting other products, respectively, classified according to the product of chief value.

There is considerable overlapping between the three subclassifications, as soap stock to the value of \$598,876 was made by those establishments rendering tallow and other products, while tallow to the value of \$265,491 was reported by those making soap stock, and other products to the value of \$23,858 were made by tallow plants. In addition, soap stock to the value of \$1,209,334 was reported by the fertilizer industry, and to the value of \$3,742,747 by slaughtering and meat-packing establishments, while establishments assigned to other classifica-

tions, principally glue, reported soap stock to the value of \$1,311,839.

Tallow to the value of \$12,371,206 was reported by slaughtering and meat-packing establishments, and to the value of \$744,143 by establishments assigned to other classifications, principally oleo oil. These amounts are in addition to the products shown in the tables.

#### LUBRICATING GREASES

This classification includes establishments engaged primarily in the manufacture of grease lubricating compounds and axle grease for automobiles, carriages, wagons, and railway cars. The industry was known as "axle grease" prior to 1914, and was first reported separately at the census of 1879.

In addition to the products covered by Table 106 petroleum refineries reported the production of lubricating and axle greases to the value of \$2,293,103, in

TABLE 114

#### GAS, ILLUMINATING AND HEATING

|                                                                         | 1914          | 1909          |
|-------------------------------------------------------------------------|---------------|---------------|
| Number of establishments                                                | 1,284         | 1,296         |
| Commercial                                                              | 1,146         | 1,177         |
| Municipal                                                               | 138           | 119           |
| Number manufacturing—                                                   |               |               |
| Straight coal gas                                                       | 277           | 343           |
| Carbureted water gas                                                    | 430           | 325           |
| Mixed coal and water gas                                                | 147           | 154           |
| Oil gas                                                                 | 153           | 179           |
| Acetylene                                                               | 165           | 158           |
| All other gas (gasoline, cold process)                                  | 112           | 137           |
| Number operating gas and electric light and power plants in conjunction | 385           | 389           |
| Total cost                                                              | \$76,779,288  | \$52,427,844  |
| Coal used for gas making:                                               |               |               |
| Tons (2,000 pounds)                                                     | 6,116,672     | 4,940,598     |
| Cost                                                                    | \$20,872,517  | \$16,304,832  |
| Oil used for gas making:                                                |               |               |
| Gallons                                                                 | 715,418,623   | 578,309,411   |
| Cost                                                                    | \$24,720,998  | \$17,105,981  |
| Benzene or benzol:                                                      |               |               |
| Purchased—                                                              |               |               |
| Gallons                                                                 | 388,146       | 253,837       |
| Cost                                                                    | \$54,653      | \$27,543      |
| Made and consumed, gallons                                              | 99,238        | 302,994       |
| Benzine, gasoline, or naphtha:                                          |               |               |
| Gallons                                                                 | 198,353       | 1,093,874     |
| Cost                                                                    | \$69,020      | \$212,226     |
| Coke used for gas making:                                               |               |               |
| Tons (2,000 pounds)                                                     | 964,851       | 591,919       |
| Cost                                                                    | \$4,500,289   | \$2,667,706   |
| Calcium carbide:                                                        |               |               |
| Pounds                                                                  | 31,749,491    | 6,080,465     |
| Cost                                                                    | \$887,937     | \$195,836     |
| Gas purchased:                                                          |               |               |
| Cubic feet, thousands                                                   | 28,351,074    | 16,769,705    |
| Cost                                                                    | \$8,883,016   | \$5,416,601   |
| Fuel for boilers and retorts                                            |               |               |
| Cubic feet, thousands                                                   | \$3,784,911   | \$2,369,131   |
| Amount paid for lamps and appliances purchased                          |               |               |
| For sale                                                                | \$7,393,224   | \$5,537,936   |
| All other materials                                                     | \$5,512,723   | \$2,590,052   |
| Total value                                                             | \$220,237,790 | \$166,814,371 |
| Gas:                                                                    |               |               |
| For sale—                                                               |               |               |
| Cubic feet, thousands                                                   | 203,639,260   | 150,835,793   |
| Value                                                                   | \$175,065,920 | \$138,615,309 |
| Average value 1,000 cubic feet                                          | \$0 86        | \$0 92        |
| Made and consumed, 1,000 cubic feet                                     | 1,121,108     | 1,730,563     |
| Straight coal—                                                          |               |               |
| Cubic feet, thousands                                                   | 10,509,946    | 19,985,253    |
| Value                                                                   | \$10,726,514  | \$18,065,841  |
| Average value 1,000 cubic feet                                          | \$1 02        | \$0 90        |
| Carbureted water—                                                       |               |               |
| Cubic feet, thousands                                                   | 90,017,725    | 81,144,568    |
| Value                                                                   | \$54,516,534  | \$70,802,780  |
| Average value 1,000 cubic feet                                          | \$0 83        | \$0 87        |
| Mixed coal and water—                                                   |               |               |
| Cubic feet, thousands                                                   | 86,281,339    | 40,775,283    |
| Value                                                                   | \$72,012,021  | \$36,953,543  |
| Average value 1,000 cubic feet                                          | \$0 83        | \$0 91        |
| Oil—                                                                    |               |               |
| Cubic feet, thousands                                                   | 16,512,274    | 8,688,860     |
| Value                                                                   | \$15,044,509  | \$12,111,458  |
| Average value 1,000 cubic feet                                          | \$0 91        | \$1 39        |
| Acetylene—                                                              |               |               |
| Cubic feet, thousands                                                   | 14,868        |               |
| Value                                                                   | \$194,019     |               |
| Average value 1,000 cubic feet                                          | \$13 05       | 25 186        |
| Delivered in containers (compressed)—                                   |               |               |
| Cubic feet, thousands                                                   | 121,696       | \$361,348     |
| Value                                                                   | \$2,317,605   | \$14 35       |
| Average value 1,000 cubic feet                                          | \$19 04       |               |
| All other gas (gasoline, cold process)—                                 |               |               |
| Cubic feet, thousands                                                   | 181,412       | 216,643       |
| Value                                                                   | \$254,718     | \$320,339     |
| Average value 1,000 cubic feet                                          | \$1 40        | \$1 48        |

| Products—Continued                                                 | 1914         | 1909             |
|--------------------------------------------------------------------|--------------|------------------|
| Coke:                                                              |              |                  |
| Production, bushels                                                | 179,128,257  | 131,599,836      |
| For sale—                                                          |              |                  |
| Bushels                                                            | 114,091,753  | 82,049,683       |
| Value                                                              | \$8,719,920  | \$5,723,215      |
| Made and consumed, bushels                                         | 65,036,504   | 49,550,153       |
| Tar:                                                               |              |                  |
| Production, gallons                                                | 153,311,196  | 109,930,058      |
| For sale—                                                          |              |                  |
| Gallons                                                            | 125,938,607  | 78,339,880       |
| Value                                                              | \$3,252,765  | \$1,875,549      |
| Made and consumed, gallons                                         | 27,372,589   | 31,590,178       |
| Ammonia liquors (16-ounce strength):                               |              |                  |
| Gallons                                                            | 50,737,762   | 37,277,864       |
| Value                                                              | \$1,235,442  | \$725,702        |
| Ammonium sulphate:                                                 |              |                  |
| Pounds                                                             | 6,216,618    | ( <sup>1</sup> ) |
| Value                                                              | \$334,196    | ( <sup>1</sup> ) |
| Hydrocarbons                                                       | \$35,902     | \$44,509         |
| All other products                                                 | \$20,815,871 | \$12,786,697     |
| Receipts from rents and sales of lamps and appliances              | \$10,977,774 | \$7,043,390      |
| Candlepower—average for the year:                                  |              |                  |
| Number of establishments reporting candlepower—                    |              |                  |
| 15 and less                                                        | 50           | 34               |
| 16 and 17                                                          | 290          | 228              |
| 18, 19 and 20                                                      | 431          | 405              |
| 21, 22 and 23                                                      | 153          | 179              |
| 24 and over                                                        | 131          | 291              |
| Number not reporting candlepower                                   | 229          | 159              |
| British thermal units—per cubic foot:                              |              |                  |
| Number of establishments reporting B. t. units—                    |              |                  |
| Less than 500                                                      | 3            |                  |
| 500 to 599                                                         | 163          |                  |
| 600 to 699                                                         | 577          |                  |
| 700 to 899                                                         | 11           | ( <sup>1</sup> ) |
| 900 to 1,300                                                       | 45           |                  |
| Over 1,300                                                         | 11           |                  |
| Number not reporting B. t. units                                   | 474          |                  |
| Miles of mains                                                     | 58,727       | 45,119           |
| Gas stoves and heaters, number connected with mains at end of year | 5,168,924    | 3,603,435        |

<sup>1</sup> Figures not available.

<sup>2</sup> Includes 61 Pintch gas and 4 Blau gas.

<sup>3</sup> Includes 40 without distributing mains; gas sold compressed in cylinders.

<sup>4</sup> Number operated under same company name: 1914, 377; 1909, 372.

<sup>5</sup> Includes amount paid for lamps and appliances, \$4,013,885, not included in Table 223.

<sup>6</sup> In addition the following products of gas manufacture were produced commercially by 6 establishments in 1914 and 4 in 1909, engaged primarily in other lines of manufacture:

| Products, total value                                                   | 1914      | 1909      |
|-------------------------------------------------------------------------|-----------|-----------|
| Gas:                                                                    | \$158,743 | \$261,802 |
| Cubic feet, thousands                                                   | 56,939    | 40,628    |
| Straight coal                                                           | 41,744    | 27,558    |
| Carbureted water                                                        | 10,154    |           |
| Acetylene (compressed)                                                  | 5,041     | 13,070    |
| Value                                                                   | \$131,979 | \$254,037 |
| Coke:                                                                   |           |           |
| Bushels                                                                 | 114,371   | 44,347    |
| Value                                                                   | \$9,356   | \$3,399   |
| Tar:                                                                    |           |           |
| Gallons                                                                 | 35,100    | 38,370    |
| Value                                                                   | \$2,076   | \$1,372   |
| Receipts from rents and sales of lamps and appliances                   | \$15,332  | \$2,994   |
| <sup>1</sup> Includes 47 Pintch gas, 18 acetylene, and 28 gasoline gas. |           |           |
| <sup>2</sup> Chiefly Pintch gas, acetylene, and Blau gas.               |           |           |
| <sup>3</sup> Includes only those of which the company has record        |           |           |

1914, and establishments assigned to other classifications, principally those making fish and miscellaneous oils, reported lubricating grease to the value of \$1,755,586.

#### INK, PRINTING

The mixing of boiled oil or varnish with black or other pigments to be used in printing is the principal business of establishments in this classification, which includes printing, lithographing, and embossing inks, colored inks, and gold and bronze ink. At the censuses of 1849 and 1879 there was no separate presentation of the statistics, the classification "ink" including both printing and writing ink.

In addition to the products covered by Table 106 printing inks to the value of \$177,672 in 1914 and of \$9,839 in 1909 were reported by establishments assigned to other industries, principally "bags, other than paper," "paints," and "stationary goods, not elsewhere specified."

#### INK, WRITING

Establishments under this classification manufacture inks consisting principally of an infusion of galls, copperas, gum arabic, and pigments of various kinds. At the censuses of 1849 and 1879 only the totals for "ink" of all kinds were given. Establishments making writing inks also reported the manufacture of mucilage and paste in 1914 to the value of \$616,926. This is included in the value of products shown in the table.

In addition to the value given in Table 106 writing ink to the value of \$67,508, in 1914, and of \$59,965, in 1909, was reported by establishments assigned to other classifications, principally those making glue, typewriter ribbons, mucilage, and polishing preparations.

#### OIL, COTTONSEED AND CAKE

The establishments under this classification are engaged primarily in the manufacture of oil, cake and meal, hulls, and linters from cotton seed, and in some cases in the refining of oil. Table 115 presents the statistics for cottonseed products for the last four censuses.

TABLE 115  
COTTONSEED PRODUCTS (TONS OF 2,000 POUNDS)

|                                                                     | 1914          | 1909          |
|---------------------------------------------------------------------|---------------|---------------|
| Cottonseed, crushed, tons                                           | 4,790,774     | 3,798,549     |
| Products, total value                                               | \$212,127,024 | \$147,867,894 |
| Primary products manufactured, whether for sale or for further use: |               |               |
| Crude oil, gallons                                                  | 191,163,261   | 157,115,689   |
| Cake and meal, tons                                                 | 2,191,610     | 1,661,734     |
| Hulls, tons                                                         | 1,385,940     | 1,258,612     |
| Linters, pounds                                                     | 330,624,502   | 174,620,099   |

In addition, cottonseed products to the value of \$2,638,390 in 1914 and of \$2,017,305 in 1909 were reported by establishments assigned to other industries. These establishments crushed, in 1914, 56,854 tons of seed and produced 2,169,758 gallons of crude oil, 25,768 tons of cake and meal, 16,969 tons of hulls, and 3,492,011 pounds of linters. In 1909 they crushed 28,752 tons of seed, and produced 1,212,852 gallons of crude oil, 12,811 tons of cake and meal, 8926 tons of hulls, and 1,152,978 pounds of linters.

#### OIL, ESSENTIAL

Establishments under this classification extract or distill the oils of various plants, such as peppermint, spearmint, wormwood, pennyroyal, wintergreen, fleabane,

tansy, and fireweed. Black birch, spruce, cedar, juniper and sassafras oils, peppermint-camphor (menthol) and witch-hazel extract are among the products.

The decrease in the value of products for the decade 1869-1879 may be accounted for on the supposition that in 1869 the production on farms was included in the manufacturers' statistics, and that in 1879 it was given with statistics of agriculture. The depreciated currency of 1869 also increased the nominal value of the products that year by about one-fifth.

The quantity and value of the natural oils, and of witch-hazel extract produced, and the value of all other products of the essential-oil industry for 1914 and 1909 are shown in Table 116.

TABLE 116

| ESSENTIAL OILS           |          | 1914 <sup>1</sup> | 1909 <sup>2</sup> |
|--------------------------|----------|-------------------|-------------------|
| Number of establishments | Products | 107               | 74                |
| Total value              |          | \$2,565,361       | \$1,773,304       |
| Essential oil, value     |          | \$1,289,482       | \$1,111,805       |
| Peppermint—              |          |                   |                   |
| Pounds                   |          | 363,991           | 305,781           |
| Value                    |          | \$601,617         | \$519,079         |
| Spearmint—               |          |                   |                   |
| Pounds                   |          | 94,209            | 33,400            |
| Value                    |          | \$238,074         | \$83,283          |
| Black birch—             |          |                   |                   |
| Pounds                   |          | 41,178            | 67,053            |
| Value                    |          | \$67,691          | \$102,045         |
| Wintergreen—             |          |                   |                   |
| Pounds                   |          | 6,000             | 22,281            |
| Value                    |          | \$24,538          | \$68,983          |
| Wormwood—                |          |                   |                   |
| Pounds                   |          | 4,702             |                   |
| Value                    |          | \$9,040           | \$338,415         |
| Other essential oils     |          | \$348,522         |                   |
| Witch-hazel extracts:    |          |                   |                   |
| Gallons                  |          | 917,690           | 691,823           |
| Value                    |          | \$575,938         | \$419,793         |
| All other products       |          | \$699,941         | \$241,706         |

<sup>1</sup> Includes two establishments in 1914 and six in 1909 which were engaged primarily in other industries

#### OIL, LINSEED

The expressing of oil from flaxseed is the chief business of the establishments in this classification, but oil cake and meal and ground flaxseed were also among the products. Linseed oil is used principally in mixing paints. In addition to the products covered by Table 106 raw linseed oil to the value of \$1,201,839 in 1914 and to the value of \$1,106,181 in 1909 was made for sale in paint and varnish factories, and to the value of \$84,408 in 1914 and of \$63,100 in 1909, by establishments assigned to other industries.

#### OIL, NOT ELSEWHERE SPECIFIED

The compounding and blending of mineral, animal, and vegetable oils for lubricating purposes and the manufacture of castor oil, oleo oil, fish or whale oil, resinol and neat's-foot oil, floor oil, signal oil, coconut oil, wool oil, palm oil, and lard oil etc. constitute the operation carried on by the establishments in this classification.

Table 106 gives separate figures for the establishments whose products of chief value were "fish oil," "oleo oil," and "all other" oils. In addition to the products covered by the table, oil to the value of \$778,337, chiefly "fish oil," was reported by manufacturers of fertilizers, and "fish oil" to the value of \$164,373 by establishments assigned to other classifications, principally those making miscellaneous oils and grease and tallow.

Oleo oil was reported by slaughtering and meat-packing establishments to the value of \$11,925,832 and



by grease and tallow factories to the value of \$471,771. In 1909, slaughtering and meat-packing establishments reported oleo oil to the value of \$16,475,726, and miscellaneous oils to the value of \$6,350,745, while fertilizers reported oils to the value of \$810,938, and establishments assigned to other classifications reported oils to the value of \$2,651,710.

Miscellaneous oils to the value of \$4,009,602 were reported by slaughtering and meat-packing establishments and to the value of \$3,400,175 by establishments assigned to other classifications, principally those making fish oil, paints, chemicals, food preparations, soap stock, and starch.

### PAINT AND VARNISH

**Paints.**—The principal products of establishments in this industry are pigments, and the mixtures of these with linseed oil, turpentine, benzine, wood alcohol etc. which constitute paint in paste or ready for use. Water paints and kalsomine, stains, and putty are also among

the products. The manufacture of white lead or of zinc white is the sole or principal business of some concerns, while some are engaged solely in paint mixing, using the materials made by other establishments. There is thus considerable duplication in the gross value of products for the industry as a whole. Many manufacturing and other concerns mix paints for their own use, the value of which is not reported; but the materials used for such paints are mainly covered by the data for the paint and varnish, linseed oil and turpentine and rosin industries.

**Varnishes.**—The establishments in the varnish industry manufacture principally varnishes consisting of solutions of gums of various kinds, or of resins, in solvents such as alcohol, linseed oil, turpentine, naphtha and benzine. Among the products are the black varnishes called japans, enamels, and fillers made of linseed oil with powdered glass, ground slate, or silica. In some instances in both paint and varnish establishments other products are reported as made for sale, such as linseed

TABLE 117

## PAINT AND VARNISH

|                                                                      | 1914          | 1909             |
|----------------------------------------------------------------------|---------------|------------------|
| Number of establishments                                             | 856           | 863              |
| Paint industry                                                       | 585           | 588              |
| Varnish industry                                                     | 215           | 203              |
| Establishments manufacturing paint or varnish as subsidiary products | 56            | 72               |
| Certain specified materials used:                                    |               |                  |
| Pig lead—                                                            |               |                  |
| Tons (2,000 pounds)                                                  | 150,762       | 150,163          |
| Cost                                                                 | \$11,488,113  | \$12,380,524     |
| Grain alcohol—                                                       |               |                  |
| Gallons                                                              | 1,061,324     | 356,225          |
| Cost                                                                 | \$436,509     | \$226,724        |
| Wood alcohol                                                         |               |                  |
| Gallons                                                              | 987,451       | 1,325,807        |
| Cost                                                                 | \$422,122     | \$693,362        |
| Linseed oil—                                                         |               |                  |
| Gallons                                                              | 24,481,623    | ( <sup>1</sup> ) |
| Cost                                                                 | \$12,049,218  | ( <sup>1</sup> ) |
| Gums—                                                                |               |                  |
| Pounds                                                               | 48,902,000    | ( <sup>1</sup> ) |
| Cost                                                                 | \$4,797,944   | ( <sup>1</sup> ) |
| Products                                                             |               |                  |
| Total value                                                          | \$149,130,873 | \$127,472,819    |
| Paint industry                                                       | \$112,408,742 | \$94,572,005     |
| Varnish industry                                                     | \$33,214,949  | \$30,317,417     |
| Subsidiary products from other industries                            | \$3,507,182   | \$2,583,397      |
| Colors (pigments) <sup>2</sup>                                       | \$17,407,955  | \$18,134,869     |
| White lead                                                           |               |                  |
| Production, pounds                                                   | 279,269,860   | 247,971,503      |
| For sale—                                                            |               |                  |
| Pounds                                                               | 71,643,812    | 85,269,414       |
| Value                                                                | \$3,697,702   | \$3,924,528      |
| Made and consumed, pounds                                            | 207,626,048   | 162,702,089      |
| Lead oxides                                                          |               |                  |
| Production, pounds                                                   | 61,335,290    | 70,293,679       |
| For sale—                                                            |               |                  |
| Pounds                                                               | 58,642,588    | 65,767,254       |
| Value                                                                | \$3,281,716   | \$3,798,551      |
| Made and consumed, pounds                                            | 2,692,702     | 7,526,425        |
| Barites—                                                             |               |                  |
| Pounds                                                               | 46,920,380    | 56,254,838       |
| Value                                                                | \$325,922     | \$348,470        |
| Iron buff and other earth colors                                     |               |                  |
| Pounds                                                               | 92,896,956    | 213,285,734      |
| Value                                                                | \$797,819     | \$1,085,438      |
| Lithopone—                                                           |               |                  |
| Pounds                                                               | 48,972,062    |                  |
| Value                                                                | \$1,857,510   |                  |
| Chrome yellow                                                        |               |                  |
| Pounds                                                               | 5,747,317     |                  |
| Value                                                                | \$641,534     |                  |
| Orange or green—                                                     |               |                  |
| Pounds                                                               | 8,024,409     |                  |
| Value                                                                | \$677,329     |                  |
| Prussian blue                                                        |               |                  |
| Pounds                                                               | 1,239,382     | 163,713,582      |
| Value                                                                | \$367,077     | \$6,523,728      |
| Ultramarine—                                                         |               |                  |
| Pounds                                                               | 2,698,639     |                  |
| Value                                                                | \$222,769     |                  |
| Other dry colors                                                     |               |                  |
| Pounds                                                               | 95,616,993    |                  |
| Value                                                                | \$3,616,445   |                  |
| Vermilion (true) —                                                   |               |                  |
| Pounds                                                               | 322,759       | 259,558          |
| Value                                                                | \$200,134     | \$107,472        |
| Fine colors not elsewhere specified—                                 |               |                  |
| Pounds                                                               | 4,210,874     | 8,420,120        |
| Value                                                                | \$690,235     | \$1,052,443      |
| Pulp colors, sold moist—                                             |               |                  |
| Pounds                                                               | 21,420,854    | 28,600,222       |
| Value                                                                | \$1,011,763   | \$1,294,239      |

| Products—Continued.                                 | 1914         | 1909             |
|-----------------------------------------------------|--------------|------------------|
| Paints                                              | \$70,582,461 | \$57,380,539     |
| In paste form, ground in oil—                       |              |                  |
| White lead—                                         |              |                  |
| Pounds                                              | 281,417,563  | 246,569,970      |
| Value                                               | \$18,141,444 | \$15,234,530     |
| Zinc—                                               |              |                  |
| Pounds                                              | 9,551,840    |                  |
| Value                                               | \$730,918    |                  |
| All other—                                          |              |                  |
| Pounds                                              | 129,042,658  | 165,038,353      |
| Value                                               | \$10,165,819 | \$11,433,937     |
| In oil already mixed for use—                       |              |                  |
| Gallons                                             | 40,745,563   | 34,278,989       |
| Value                                               | \$41,544,280 | \$30,710,063     |
| Varnishes and japans                                | \$36,142,256 | \$31,758,735     |
| Oleoresinous varnishes—                             |              |                  |
| Gallons                                             | 17,801,438   | 18,692,527       |
| Value                                               | \$18,762,399 | \$17,359,898     |
| Spirit varnishes, not turpentine—                   |              |                  |
| Gallons                                             | 2,964,172    | 1,273,411        |
| Value                                               | \$3,080,425  | \$1,502,398      |
| Damar and similar turpentine and benzine varnishes— |              |                  |
| Gallons                                             | 3,297,371    | 3,483,994        |
| Value                                               | \$2,865,256  | \$2,839,534      |
| Pyroxilin varnishes—                                |              |                  |
| Gallons                                             | 852,571      | 1,886,541        |
| Value                                               | \$1,308,796  | \$2,356,692      |
| Drying japans and dryers—                           |              |                  |
| Gallons                                             | 6,560,406    | 6,638,706        |
| Value                                               | \$3,015,907  | \$3,165,589      |
| Ball-japans and lacquers—                           |              |                  |
| Gallons                                             | 4,888,816    | 2,983,285        |
| Value                                               | \$2,960,856  | \$2,079,927      |
| All other—                                          |              |                  |
| Value                                               | \$4,148,617  | \$2,254,697      |
| Fillers—                                            |              |                  |
| Liquid—                                             |              |                  |
| Gallons                                             | 965,636      | 1,166,533        |
| Value                                               | \$670,033    | \$828,393        |
| Dry or in paste—                                    |              |                  |
| Pounds                                              | 49,587,548   | 65,148,395       |
| Value                                               | \$1,318,720  | \$1,199,595      |
| Putty—                                              |              |                  |
| Pounds                                              | 69,828,017   | 67,767,348       |
| Value                                               | \$1,250,421  | \$1,169,683      |
| Water paints and kalsomine—                         |              |                  |
| Dry or in paste—                                    |              |                  |
| Pounds                                              | 61,904,258   | 47,465,715       |
| Value                                               | \$2,055,180  | \$1,917,047      |
| Mixed for use—                                      |              |                  |
| Gallons                                             | 297,173      | 543,733          |
| Value                                               | \$147,101    | \$64,114         |
| Linseed oil—                                        |              |                  |
| Raw—                                                |              |                  |
| Gallons                                             | 2,230,988    | 2,098,696        |
| Value                                               | \$1,201,639  | \$1,106,181      |
| Boiled—                                             |              |                  |
| Gallons                                             | 572,561      | 1,379,025        |
| Value                                               | \$306,569    | \$806,846        |
| Other oils                                          | \$999,392    | ( <sup>1</sup> ) |
| Bleached shellac—                                   |              |                  |
| Pounds                                              | 8,654,514    | 3,905,593        |
| Value                                               | \$6,806,802  | \$772,240        |
| Acetate of lead—                                    |              |                  |
| Pounds                                              | 2,896,313    | ( <sup>1</sup> ) |
| Value                                               | \$150,587    | ( <sup>1</sup> ) |
| Driers—                                             |              |                  |
| Gallons                                             | 1,047,140    | ( <sup>1</sup> ) |
| Value                                               | \$257,725    | ( <sup>1</sup> ) |
| All other products                                  | \$14,833,832 | \$12,334,577     |

<sup>1</sup> Figures not available.

<sup>2</sup> In addition, in 1914, 106,791 tons of pigments, valued at \$9,978,710, were made by smelters direct from the ore, and 66,766 tons of natural mineral pigments, valued at \$473,076, were marketed; and in 1909, 87,525 tons of pigments, valued at \$7,963,332, were made by smelters direct from the ore, and 61,137 tons of natural mineral pigments, valued at \$613,153, were marketed.

<sup>3</sup> Includes lampblack and other carbon blacks made by paint and varnish establishments. See Table 107 for bone, carbon, and lampblack statistics.

oil, raw and boiled, and bleached shellac, but larger quantities of such products are made for use in the same establishment.

The inquiry at the present census in regard to specific materials used in the manufacture of paints and varnishes was confined to pig lead, alcohol (grain and wood), linseed oil, and gums. The statistics for paint and varnish products and the consumption of the above-named materials are given in Table 117 for 1914 and 1909.

TABLE 118  
PETROLEUM, REFINING

|                                                                                                                                       | 1914          | 1909             |
|---------------------------------------------------------------------------------------------------------------------------------------|---------------|------------------|
| Number of establishments.....                                                                                                         | 176           | 147              |
| <b>Materials</b>                                                                                                                      |               |                  |
| Total cost.....                                                                                                                       | \$325,264,509 | \$199,273,402    |
| Crude petroleum used <sup>1</sup>                                                                                                     |               |                  |
| Barrels (42 gallons).....                                                                                                             | 191,262,724   | 120,775,439      |
| Cost.....                                                                                                                             | \$249,727,856 | \$152,307,040    |
| California.....                                                                                                                       |               |                  |
| Barrels.....                                                                                                                          | 41,901,651    | 13,481,885       |
| Cost.....                                                                                                                             | \$30,157,013  | \$10,108,541     |
| Mid-Continent—                                                                                                                        |               |                  |
| Barrels.....                                                                                                                          | 92,462,637    | 42,895,051       |
| Cost.....                                                                                                                             | \$121,186,441 | \$41,959,100     |
| Pennsylvania grade—                                                                                                                   |               |                  |
| Barrels.....                                                                                                                          | 21,196,964    | 24,508,218       |
| Cost.....                                                                                                                             | \$50,019,939  | \$47,545,138     |
| Illinois—                                                                                                                             |               |                  |
| Barrels.....                                                                                                                          | 17,672,279    | 26,236,883       |
| Cost.....                                                                                                                             | \$30,137,986  | \$36,218,407     |
| Gulf—                                                                                                                                 |               |                  |
| Barrels.....                                                                                                                          | 5,787,313     | 5,262,664        |
| Cost.....                                                                                                                             | \$6,080,907   | \$4,669,486      |
| Lima-Indiana—                                                                                                                         |               |                  |
| Barrels.....                                                                                                                          | 2,564,742     | 8,083,096        |
| Cost.....                                                                                                                             | \$4,286,588   | \$11,455,764     |
| Colorado and Wyoming—                                                                                                                 |               |                  |
| Barrels.....                                                                                                                          | 3,441,893     | 307,642          |
| Cost.....                                                                                                                             | \$2,088,700   | \$350,604        |
| Mexican—                                                                                                                              |               |                  |
| Barrels.....                                                                                                                          | 6,235,245     | ( <sup>2</sup> ) |
| Cost.....                                                                                                                             | \$5,768,282   | ( <sup>2</sup> ) |
| Partly refined oils and waxes purchased:                                                                                              |               |                  |
| Barrels (50 gallons).....                                                                                                             | 7,942,444     | ( <sup>2</sup> ) |
| Cost.....                                                                                                                             | \$24,395,541  | ( <sup>2</sup> ) |
| Caustic soda:                                                                                                                         |               |                  |
| Tons.....                                                                                                                             | 11,108        |                  |
| Cost.....                                                                                                                             | \$361,421     |                  |
| Sulphur and pyrites.....                                                                                                              | \$206,053     |                  |
| Sulphuric acid:                                                                                                                       |               |                  |
| Consumption, tons (2,000 pounds).....                                                                                                 | 328,895       | \$4,003,198      |
| Purchased—                                                                                                                            |               |                  |
| Tons.....                                                                                                                             | 200,455       |                  |
| Cost.....                                                                                                                             | \$3,519,552   |                  |
| Made and consumed, tons.....                                                                                                          | 38,440        | 48,580           |
| Containers and materials therefor:                                                                                                    |               |                  |
| Wooden.....                                                                                                                           | \$12,944,471  | \$8,937,421      |
| Metal.....                                                                                                                            | \$7,292,207   | \$8,037,467      |
| Fuel and rent of power.....                                                                                                           | \$13,567,284  | \$8,376,383      |
| All other materials.....                                                                                                              | \$13,250,124  | \$17,611,893     |
| <b>Products</b>                                                                                                                       |               |                  |
| Total value.....                                                                                                                      | \$396,361,406 | \$236,997,659    |
| Naphthas and lighter products:                                                                                                        |               |                  |
| Gasoline (petroleum refineries)—                                                                                                      |               |                  |
| Barrels (50 gallons).....                                                                                                             | \$23,908,242  |                  |
| Value.....                                                                                                                            | \$106,140,170 |                  |
| All other:                                                                                                                            |               |                  |
| Barrels.....                                                                                                                          | 5,292,522     | 10,806,550       |
| Value.....                                                                                                                            | \$15,779,137  | \$39,771,959     |
| Illuminating oils:                                                                                                                    |               |                  |
| Barrels.....                                                                                                                          | 38,705,496    | 33,495,798       |
| Value.....                                                                                                                            | \$96,806,452  | \$94,547,010     |
| Fuel oils:                                                                                                                            |               |                  |
| Barrels.....                                                                                                                          | 74,681,841    | 34,034,577       |
| Value.....                                                                                                                            | \$84,017,916  | \$36,462,883     |
| Distillates:                                                                                                                          |               |                  |
| Barrels.....                                                                                                                          | 9,149,833     | ( <sup>2</sup> ) |
| Value.....                                                                                                                            | \$15,979,342  | ( <sup>2</sup> ) |
| Gas oils:                                                                                                                             |               |                  |
| Barrels.....                                                                                                                          | 15,111,168    | ( <sup>2</sup> ) |
| Value.....                                                                                                                            | \$22,805,340  | ( <sup>2</sup> ) |
| Residual fuel oils—                                                                                                                   |               |                  |
| Value.....                                                                                                                            | \$0,420,840   |                  |
| Value.....                                                                                                                            | \$45,213,234  | ( <sup>2</sup> ) |
| Lubricating oils:                                                                                                                     |               |                  |
| Barrels.....                                                                                                                          | 10,356,776    | 10,745,885       |
| Value.....                                                                                                                            | \$55,612,120  | \$38,884,236     |
| Pale or paraffin; viscosity less than 100 per cent Universal; or flash under 400 per cent Fahrenheit, closed cup—                     |               |                  |
| Barrels.....                                                                                                                          | 1,868,442     | 3,239,230        |
| Value.....                                                                                                                            | \$8,084,650   | \$9,473,975      |
| Red or neutral; viscosity 100 per cent Universal; or flash 400 per cent Fahrenheit, or over closed cup (not including cylinder oils)— |               |                  |
| Barrels.....                                                                                                                          | 2,327,050     | 614,884          |
| Value.....                                                                                                                            | \$12,426,023  | \$2,255,924      |
| Cylinder oils—                                                                                                                        |               |                  |
| Barrels.....                                                                                                                          | 2,058,982     | 1,587,579        |
| Value.....                                                                                                                            | \$13,703,772  | \$9,482,568      |

## PETROLEUM, REFINING

All crude petroleum refineries are included under this classification. The principal products are illuminating fuel, and lubricating oils, gasoline, and paraffin wax. Other products are lubricating and other greases, oil asphaltum, coke, black naphtha, tar, and sludge acid and residuums.

The products of the petroleum-refining industry, statistics for which are presented in Table 118, aggregated \$396,361,406 in value in 1914, as compared with \$236,-

|                                                                          | 1914          | 1909             |
|--------------------------------------------------------------------------|---------------|------------------|
| <b>Products—Continued</b>                                                |               |                  |
| All other lubricating oils, including compounded (except cylinder) oils— |               |                  |
| Barrels.....                                                             | 4,102,302     | 75,304,192       |
| Value.....                                                               | \$21,597,675  | \$17,671,769     |
| Residuum or tar, including liquid asphaltic road oils:                   |               |                  |
| Barrels.....                                                             | 2,696,887     | 1,787,008        |
| Value.....                                                               | \$4,017,858   | \$2,215,623      |
| Greases:                                                                 |               |                  |
| Barrels.....                                                             | 280,128       | 138,302          |
| Value.....                                                               | \$3,536,491   | \$1,567,647      |
| Petroleum, mineral jelly, etc.—                                          |               |                  |
| Barrels.....                                                             | 121,561       | ( <sup>2</sup> ) |
| Value.....                                                               | \$1,243,388   | ( <sup>2</sup> ) |
| Lubricating greases—                                                     |               |                  |
| Barrels.....                                                             | 99,603        | ( <sup>2</sup> ) |
| Value.....                                                               | \$1,624,949   | ( <sup>2</sup> ) |
| Axle greases—                                                            |               |                  |
| Barrels.....                                                             | 58,964        | ( <sup>2</sup> ) |
| Value.....                                                               | \$668,154     | ( <sup>2</sup> ) |
| Paraffin wax:                                                            |               |                  |
| Barrels.....                                                             | 1,150,776     | 946,830          |
| Value.....                                                               | \$8,897,106   | \$9,388,812      |
| Asphalt, other than liquid asphalt:                                      |               |                  |
| Tons (2,000 pounds).....                                                 | 465,157       | 233,128          |
| Value.....                                                               | \$4,867,213   | \$2,724,752      |
| Coke:                                                                    |               |                  |
| Tons.....                                                                | 213,777       | ( <sup>2</sup> ) |
| Value.....                                                               | \$818,889     | \$507,695        |
| Reclaimed or separated acid sold (calculated at 66° Baumé):              |               |                  |
| Tons.....                                                                | 89,792        | 133,215          |
| Value.....                                                               | \$491,380     | \$402,295        |
| Candles.....                                                             | \$1,402,945   |                  |
| (Other special products.....)                                            | \$8,507,993   |                  |
| All other products.....                                                  | \$5,265,736   | \$10,524,747     |
| <b>Equipment</b>                                                         |               |                  |
| Stills, number.....                                                      | 3,639         | 2,395            |
| Steam.....                                                               |               |                  |
| Number.....                                                              | 612           | 467              |
| Capacity (barrels, 42 gallons).....                                      | 426,000       | 431,000          |
| Fire—                                                                    |               |                  |
| Number.....                                                              | 3,027         | 1,928            |
| Capacity.....                                                            | 2,021,000     | 1,657,000        |
| Agitators.....                                                           | 770           | 529              |
| Chilling houses for paraffin.....                                        | 76            | 79               |
| Hydraulic or other presses.....                                          | 459           | 357              |
| Storage tanks for—                                                       |               |                  |
| Crude petroleum.....                                                     |               |                  |
| Number.....                                                              | 1,014         | 678              |
| Capacity (gallons).....                                                  | 580,202,000   | 242,591,000      |
| Refined petroleum products—                                              |               |                  |
| Number.....                                                              | 6,967         | 6,476            |
| Capacity.....                                                            | 1,042,836,000 | 1,041,627,000    |
| Fuel oil—                                                                |               |                  |
| Number.....                                                              | 807           |                  |
| Capacity.....                                                            | 343,132,000   |                  |
| Other storage tanks—                                                     |               |                  |
| Number.....                                                              | 4,111         | ( <sup>2</sup> ) |
| Capacity.....                                                            | 646,608,000   | ( <sup>2</sup> ) |

<sup>1</sup> Crude petroleum production (United States Geological Survey) and refinery consumption, by fields:

|                                                                | 1914                             |                                 | 1909                             |                                 |
|----------------------------------------------------------------|----------------------------------|---------------------------------|----------------------------------|---------------------------------|
|                                                                | Production<br>(United<br>States) | Consumption<br>by<br>Refineries | Production<br>(United<br>States) | Consumption<br>by<br>Refineries |
| Total number of barrels<br>(42 gallons).....                   | 265,762,535                      | 191,262,724                     | 183,170,874                      | 120,775,439                     |
| California.....                                                | 99,775,327                       | 41,901,651                      | 55,471,601                       | 13,481,885                      |
| Mid-continent (Kansas<br>Oklahoma, etc.).....                  | 97,995,400                       | 92,462,637                      | 50,833,740                       | 42,895,051                      |
| Pennsylvania grade (Appalachian).....                          | 24,101,048                       | 21,196,964                      | 26,535,844                       | 24,508,218                      |
| Illinois.....                                                  | 21,919,749                       | 17,672,279                      | 30,898,339                       | 26,236,883                      |
| Gulf.....                                                      | 13,117,528                       | 5,787,313                       | 10,883,240                       | 5,262,664                       |
| Lima, Indiana.....                                             | 5,062,543                        | 2,564,742                       | 8,211,443                        | 8,083,096                       |
| Colorado, Wyoming, and<br>other fields (United<br>States)..... | 3,790,940                        | 3,441,893                       | 336,667                          | 307,642                         |
| Mexican.....                                                   |                                  | 6,235,245                       |                                  |                                 |

<sup>2</sup> Figures not available. <sup>3</sup> Included under "All other materials."

<sup>4</sup> Quantities represented, sulphur 2,035 tons, pyrites 23,669 tons.

<sup>5</sup> Includes "wet" natural gas estimated at 1,500,208 thousand cubic feet, cost \$92,476, used by refineries.

<sup>6</sup> The production of casing-head gasoline—that made at the wells from natural gas—was 853,053 barrels (42,652,632 gallons). Excluding duplication on account of casing-head gasoline reported by refineries the total production of gasoline was 24,711,565 barrels (50 gallons).

<sup>7</sup> Includes 2,564,812 barrels reported as reduced oil.

<sup>8</sup> Includes partly finished stock, paraffin acid oil, tree sprays, etc.

997,659 in 1909, the increase during the last decade (1904-1914) being 126.5 per cent. This conforms closely to the increase in the cost of crude petroleum used, which was 132.3 per cent. The crude petroleum used increased in quantity from 66,982,862 barrels of 42 gallons in 1904 to 191,262,724 barrels in 1914, or 185.5 per cent, and the refined-oil products aggregated 40,290,985 barrels of 50 gallons in 1899, 46,454,062 barrels in 1904, 89,082,810 barrels in 1909, and 152,944,877 barrels in 1914, an increase for the last decade of 229.2 per cent.

### SALT

All establishments producing salt, whether by mining or by evaporation, as well as those refining salt, are included in this classification. The products include brine, bromine, and calcium chloride. The major part of the business is of the nature of manufacturing rather than of mining or extracting material from the earth.

Statistics of the materials and products for this industry are collected annually by the United States Geological Survey, therefore such data were not reported to the census in 1914. Table 119 gives the totals for that year as compiled by the United States Geological Survey in comparison with those for the census of 1909.

| Product                               | SALT | 1914         | 1909         |
|---------------------------------------|------|--------------|--------------|
| Total value.....                      |      | \$14,070,333 | \$11,327,834 |
| Salt:                                 |      |              |              |
| Barrels.....                          |      | 134,804,683  | 29,933,060   |
| Value.....                            |      | \$10,271,358 | \$8,311,729  |
| Bromine:                              |      |              |              |
| Pounds.....                           |      | 576,991      | 569,725      |
| Value.....                            |      | \$203,094    | \$57,600     |
| Calcium chloride: <sup>1</sup>        |      |              |              |
| Tons (2,000 pounds).....              |      | 19,403       | 12,853       |
| Value.....                            |      | \$121,766    | \$63,198     |
| All other products, value.....        |      | \$3,474,115  | \$2,895,307  |
| Salt, classified by grade (barrels):  |      |              |              |
| Table and dairy.....                  |      | 4,121,574    | 3,042,824    |
| Common fine.....                      |      | 6,237,860    | 7,745,204    |
| Common coarse.....                    |      | 3,789,163    | 2,843,393    |
| Packers.....                          |      |              | 385,802      |
| Coarse solar.....                     |      | 1,080,199    | 1,109,396    |
| Rock salt, mined.....                 |      | 7,577,172    | 5,938,721    |
| Milling, other grades, and brine..... |      | 11,998,715   | 8,667,720    |

<sup>1</sup> Includes solar salt of Porto Rico.

<sup>2</sup> From natural brine; not including that obtained in connection with the manufacture of soda.

### SOAP

Establishments under this classification manufacture chiefly hard soaps, including powdered soaps, toilet, shaving and special soaps; soft soaps, and glycerine.

The statistics for the soap industry, given in Table 120 for 1914 and 1909 include those for the soap factories operated by the owners of slaughtering and meat-packing establishments, as well as for establishments engaged primarily in the manufacture of soap. In 1899 the manufacture of soap and of candles was reported as one industry, the value of products being \$53,231,017. In 1904 the value of the combined products of these industries was \$72,164,062, in 1909, \$114,488,298, and in 1914, \$129,673,164.

The cost of the materials used in the soap industry was \$88,866,786 in 1914, \$72,179,418 in 1909, and \$43,625,608 in 1904, the increase for the ten-year period being 103.7 per cent. The value of all products was \$127,942,441 in 1914, \$111,357,777 in 1909, and \$68,274,700 in 1904, the increase for the ten-year period being 87.4 per cent. With the addition of the by-products from establishments in other industries the total value of soap products was \$135,304,499 in 1914. The chief soap product was hard soap, which, including that made in establishments engaged primarily in the manu-

facture of products other than soap, aggregated 1,032,114 net tons in 1914. Glycerine is an important product of the soap industry. Reference should be made to Table 108 for the total glycerin product, including that of chemical establishments.

### TURPENTINE AND ROSIN

The establishments included in this classification distill the gum exuded from the southern pine, the distillate being turpentine and residuum rosin. Establishments engaged in the destructive distillation of wood are not included here, but under "wood distillation." The industry includes the extraction of the raw material from the trees as well as its distillation. The decrease shown in value of products during the decade 1859-1869 was due primarily to the Civil War.

Table 121 gives the quantity and value of the turpentine and rosin produced in 1914 and 1909.

| Product                              | TURPENTINE AND ROSIN |              |
|--------------------------------------|----------------------|--------------|
|                                      | 1914                 | 1909         |
| Total value.....                     | \$20,990,191         | \$25,295,017 |
| Turpentine:                          |                      |              |
| Gallons.....                         | 26,980,981           | 28,988,954   |
| Value.....                           | \$10,509,527         | \$12,654,228 |
| Rosin:                               |                      |              |
| Barrels (280 pounds).....            | 2,885,077            | 3,263,857    |
| Value.....                           | \$10,329,410         | \$12,576,721 |
| Dross and other products, value..... | \$151,254            | \$64,068     |

<sup>1</sup> In addition, in 1914, 92,401 gallons of turpentine, valued at \$36,617, and 8,027 barrels of rosin, valued at \$44,734, were reported by establishments assumed to be lumber and timber products, and 575,557 gallons of turpentine, valued at \$194,183, and 51,825 barrels of rosin, valued at \$198,165, by wood distillation. In 1909, 18,310 gallons of turpentine, valued at \$7,482, were reported by lumber manufacturers, and 706,868 gallons, valued at \$249,526, by wood distillation. In 1904, 442,185 gallons of turpentine, valued at \$176,521, were reported by wood distillation.

The total production of turpentine in all industries was 27,648,939 gallons valued at \$10,740,327 in 1914, as compared with 29,714,132 gallons, valued at \$12,911,236 in 1909.

The acreage of timber land worked in 1914 was 8,428,088, compared with 8,076,915 in 1909, making an increase of 4.6 per cent. The returns show a very great increase in the use of the cup system of gathering crude gum. In 1914 the number of crops (of 10,500 cups) worked was 11,813, as compared with only 2,383 in 1909, the percentage of increase being 395.7. On the other hand, the number of crops worked by the boxing system decreased from 17,775 in 1909 to 6,353 in 1914, or 64.3 per cent. The number of crops in back-boxed timber increased from 6,795 in 1909 to 8,314 in 1914, or by 22.4 per cent.

### WOOD DISTILLATION, NOT INCLUDING TURPENTINE AND ROSIN

This classification includes establishments engaged in the manufacture of wood alcohol (methyl alcohol), pyroigneous acid, acetates, tar, turpentine, and charcoal by the destructive distillation of wood in retorts, ovens, or kilns, but does not include establishments making spirits of turpentine from the crude turpentine or gum exuded by the southern pine. The statistics include establishments engaged in the refining of crude wood alcohol. In the North the hard woods are generally used with a production of wood alcohol, while in the South wood distillation is usually confined to pine with a production of turpentine.

The statistics for materials, products, and equipment, for 1914, in comparison with those for the census of 1909, are given in Table 122.



# CHEMICAL & METALLURGICAL ENGINEERING

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Nec Timeo

Nec Sperno

THE rumor mill is always interesting and sometimes it is instructive. The latest, in regard to dyes, comes from a man who knows somebody in Switzerland who knows somebody in Sweden who knows somebody in Holland, and is as follows: After the war the Germans do not anticipate a great export of German dyestuffs and their best colors are not to be exported. Those already known are to be sold in competition against the products of other countries as opportunity offers, but the mysterious new ones, those with unheard of tintorial power and endurance and brilliancy, are to be under embargo for the benefit of German textile manufacturers. They are alleged to have such amazing lustre and bloom and glow and to be so fast against the sun and wash and bleach and wear and mud and all the vicissitudes of tintorial life that the dyes in present use will be wretched stains in comparison. We are not informed whether those with the photo-chemical properties dreamed of by Professor Ciamician, which shimmer with untold radiance as the fabrics colored with them are brought to the light, are included. He imagined a beautiful woman enrobed in such stuffs entering a brilliantly lighted room and growing more resplendent as she approaches. We might as well add this invention to the rumor to give it body and increase its stimulus.

Time has taught us that the composite German under his Prussian constitution does not play a gentleman's game in world affairs, and that if he is carefully observed and all cheating privileges are denied him, his boasting is vain and in point of ability he is no better than the other players.

In making dyes and intermediates he did get ahead of us, and his commercial methods were those of the card sharper's green table to which he so persistently invites his enemies to meet him and which his enemies so persistently decline to do. According to the rumor of the long journey, his present attitude in insisting upon the return of his colonies is to assure himself of a supply of cotton and wool (*sic*) so as to beat the world in textiles. Flax may be obtained from Russia and worked up in conquered Belgium and within the Vaterland, being provided for by the treaty made over the green table at Brest-Litovsk. For the past four years the things he has held sacred have been few in number. Lately he has added this treaty to his collection of sacred things and yet, somehow, it does not convince us of his spiritual growth.

He is a great hunter for vulnerable spots and vulnerable persons and as soon as he finds a foreigner who looks crooked or weak or mentally crippled with vanity, he approaches him with proffers of friendship and profit.

As he finds American men indisposed to accept his advances it will be no more than natural for him to appeal to American women, especially those of fashion and wealth, to buy his wares. And no matter how unwarranted the rumor as we have related it may be, we may be sure that in some way or other, he will make an ardent appeal to American women with proffers of finery after the war. The love of dress is strong among them and neither voting privileges nor political preferences are likely to overcome it. The dye industry is, in great measure, built upon it.

While the composite German is not a person of good taste, like the composite Frenchman, he is remarkable in imitation and in development of the ideas of others. Until he grows rich he is exceedingly industrious. When he has to root deep or die, he roots deep. And we may well conclude that in research in relation to dyes and textiles, he will continue to preserve. We have excellent research laboratories in connection with our leading dye-manufacturing establishments. We believe that in their facilities they are equal to those of the leading German works in time of peace and, as likely as not, somewhat better. In imagination and in chemical understanding we believe the great American laboratories to be as well if not better manned. On the other hand, we doubt if they have the many university connections that some German concerns enjoyed and used, and the American laboratories have devoted most of their time to the herculean tasks of the development of unfamiliar processes and to the achievements of quality and yield. The chances are that just now, the Germans are ahead of us in novelties. It is well to bear this in mind anyway, and to remember that as soon as we grow scornful and think they are not to be feared any more, they will rise again. At the dye symposium at the Cleveland meeting of the American Chemical Society, the chairman, Mr. R. Norris Shreve, pointed out that the American color industry cannot endure without constant and intense research—in fact, he declared that without it we are bound to fail. We cannot give too much emphasis to this wise statement, which is the very point we have been trying to illustrate.

Another report that comes by less roundabout way is that in the amalgamation of the German dye industries, the Verwaltungsrat or controlling body is made up of technically trained men. The selling staff tells what can be sold and is to report on markets while the financial advisors determine gross expenditures, but control will rest with men who do not require a treatise on chemistry to make them understand proposed measures. If they have their entire dye industry in such hands they are ahead of us in this respect. We do not want to harp on this subject too often but we are firmly convinced that the weak spot in far too many American industrial concerns is in the board of directors. A man does not think that he is entitled to sit on the board of directors of a bank because he deposits his money there, and no more should he presume to inflict his ignorance upon a manufacturing establishment because he has some money invested in it. Shareholders should be represented on boards by the co-operation and wisdom and understanding of the whole body and not by the ignorant and incompetent guardians of special interests. Such men cannot possibly understand technical problems as they arise, and they cannot judge

properly when to say yes and when to say no. It is high time to go through some boards of directors of chemical organizations with a fine-tooth comb to remove the dandruff.

## Sulphuric Acid

### A Martial Indicator

High-school chemistry text-books of twenty-five and thirty years ago contained a statement regarding sulphuric acid that always held the attention of the student even though it was beyond his comprehension. This was to the effect that the consumption of sulphuric acid is an index of the degree of civilization of a people. The reader probably will recall earlier or later statements to the same effect, having reference, of course, to the peaceful pursuits and industries of a nation. But what of sulphuric acid in war? Of what is its consumption then an index? Perhaps a terse answer would be: Of the intensity and magnitude of the military operations.

In 1917 our production was over 7,000,000 tons, nearly twice that of 1913 which may be taken as a normal pre-war year. Plainly the consumption of sulphuric acid is an index of something more than the civilization of a people.

Additional information of unusual interest is contained in the report of the U. S. Geological Survey on the production of sulphuric acid in 1917. Compared with 1913, the last normal year prior to the war, the production for 1917 was nearly twice as great, the increase occurring in the acids of strengths higher than 66 degrees Baumé. The significance of this is, of course, that acid of high strength enters into the manufacture of munitions of war, and with the nations of the world straining every resource at their command for the production of munitions at a high rate of speed and in hitherto unheard-of quantities, sulphuric acid production increased out of all proportion to peace-time outputs.

The dislocation of world trade and commerce by the war had its effect on sulphuric acid production, and for a time the uncertainty of a ready supply of sulphur was disquieting. Wholly unmindful of the machinations of the Potsdam gang, our sulphuric acid industry had been built up largely on the use of pyrites imported from Spain. Thus in 1912 we imported 970,785 long tons of pyrites containing more than 25 per cent of sulphur; in 1913, 850,592 tons; in 1914, 1,026,617. This high mark was followed by a slump in 1915 to 964,634 tons; and this, in turn, by a rise to 1,244,662 tons. In 1917 the imports fell off to the level of 1912 and 1915, amounting to only 967,340 tons.

With these disturbances it became necessary to re-adjust our industry to the use of domestic sulphur-bearing materials and in some cases to remodel plants to burn native sulphur in place of pyrites. There was a wide search for sulphur-bearing ores throughout the United States, and while it can be said that we have ample supplies of sulphur-bearing ores, this does not easily solve the problem of acid production. There has been reluctance to use certain ores, notably pyrrhotite, on account of the changes in practice which would be involved. Regardless of these difficulties, however, and the further problems of labor shortage and transportation, the industry is serving the warring nations with remarkable ability.

## Sidelights on the Exposition

IT IS not only little children that want to see the wheels go round. The crowd likes to see things moving, provided something is happening in the process that those who compose the crowd can understand. A series of mystical prayer wheels, whirling about as is shown in the last act of *The Magic Flute* will cause anybody to stop and look as he passes by, but there needs to be some sort of an answer to the prayer going on to attract his sustained attention. A number of exhibitors have availed themselves of this disposition of persons to close in and see what is happening, and with considerable success. Thus visitors hover about a Dorr thickener and a Benith rotary filter in operation. They watch a pretty glass-and-brass model of a Ruggles-Coles direct-heat dryer turning about with material passing through it. They gather around a furnace burning powdered coal designed to heat apartment houses and office buildings shown by the Powdered Coal Engineering and Equipment Co. and about the dyeing operations in process in the booth of the National Aniline & Chemical Co. We mention these merely as examples, for there are many others.

\* \* \*

The Solvay Process Co. has a thrilling panorama of a war scene. There are aeroplanes in the air, a burning village in the distance, artillery at work, tanks big and little going out, wounded men on stretchers before a dressing station, ambulances going and coming, a Y. M. C. A. hut—in short, nearly everything except the smell of battle, the noise, the misery and the hate. Then hung up above and at the sides of the picture are Solvay products and the uses to which they are put in war, all clearly indicated. The Somet-Solvay Co. also shows a connected display of coal and its products while their relations to each other are indicated by silk ribbons which bind them together.

\* \* \*

It was a happy idea to mark exhibits of things made in the U. S. for the first time since the war began with a bull's eye. We shall make note of some of these occasionally as we proceed, but we give notice here and now that these comments are in no sense a catalogue of the show. They are merely side lights and we deny all obligation to observe a proper sense of proportion.

\* \* \*

The Barrett Company displays a long list of products marked with the eye that sees red. These include anthracene, carbazol, orthocresol, meta-paracresol, various forms of paracumaron resins, resorcline, pyridine and others. The same company shows a remarkably interesting coal-tar tree of unusual detail, in which not only the names of a large number of coal-tar derivatives are given but also a sample bottle of each product, displayed in its proper place.

\* \* \*

The Anaconda Copper Mining Co. has, of course, a considerable display of copper and we also find, side by side, samples of tellurium and selenium. About an equal amount of each of these cousins to sulphur is shown, but we doubt if any copper refiner maintains the same sentiments towards both of them. We understand that there is almost a greater demand for

selenium than the market can meet whereas tellurium is still looking for a job. Here's a good chance for a doctor's degree and a fortune for some aspiring young research chemist, in the discovery of an industrial use for tellurium. The principal application of selenium is said to be in correcting the color in glass, owing to its red effect. At all events that is one large use. We heard a rumor that some of it goes into the dyestuff industry, but we are addicted to doubt in this direction. On the other hand, we throw out a suggestion free of charge to the prospective research wallah in tellurium: Why not make tellurium dyes in the place of sulphur colors? Tellurium is cheap and it has a grand heft. Moreover, next to body and bloom in color, textile people are often made glad by the excess weight that accrues to fabrics in the dye bath.

It does not take much of a strain upon the memory to recall the time when certain wise men refused to consider electrolytic zinc with that quality of faith which is the substance of things hoped for. But here it is, in handsome quantities, 99.9 per cent pure.

\* \* \*

Major F. E. Breithut, who has Uncle Sam's exhibit in charge is connected with the personnel division of the Chemical Warfare Service. He tells us that the immediate, return-mail responses to the questionnaire lately sent to chemists over his name, have numbered over 7000.

\* \* \*

The face-piece of the captured German gas-mask shown in the exhibit of the Chemical Warfare Service is made of softened leather instead of rubber, for obvious reasons. The edges are of cotton fabric, covered with some sort of varnish. The tubes are made of similar cloth and inclose coiled springs of metal, to give them the necessary elastic effect. It is a clever make-shift.

\* \* \*

Corporal Charles F. Roth of the Chemical Warfare Service is, in private life, joint manager of the Exposition with Mr. F. W. Payne, and Secretary of the New York Section of the American Chemical Society. It isn't letting the cat out of the bag to say that when, under the selective draft, Mr. Roth was called to the colors, it became necessary for his associate, Mr. Payne, to cinch up his belt and, metaphorically speaking, spit on his hands for the job ahead of him. A year ago, in the comedy of circumstances, the manager of the Exposition would, as likely as not, have been set to work to peel potatoes in some camp while the authorities were in despair to know the very things in which this cheerful corporal is peculiarly well posted: as to who makes what. A month or so ago, however, when we saw him for nearly the first time in uniform since he wore a little sailor suit as an angel child, he had just been transferred to the Chemical Warfare Service, and he was working like a beaver to speed up production. A modest, gentle-spoken soul is the corporal, far rather disposed to sweet reasonableness than to the sway of might. He is not of the shouting kind. His name has a German turn to it, but that comes from earlier generations, and we can no more imagine him making Prussian noises than we can imagine him mutilating children.



## The Direct Determination of Sulphur Dioxide in Burner Gases

BY F. N. WILLIAMS

WITH the urgent need of higher efficiency and conservation in the use of sulphur, proper burner regulation and furnace control are matters of the utmost importance.

In order to obtain the maximum yield of sulphur dioxide, either from the direct combustion of sulphur or pyrites, regular analysis of the burner gases is most imperative. In this way only can the proper air regulation and burner temperature be obtained. There are two general methods for the determination of sulphur dioxide. The first is by means of an apparatus of the Reinsch type, in which a measured volume of the gas is passed through suitable absorption bottles containing standard iodine solution. The end point is determined either by the disappearance of the color of the iodine or by the titration of the excess of iodine with sodium thiosulphite. In the writer's experience this method is open to several very serious objections, as follows: It is slow and tedious, completeness of absorption is always uncertain, as there is no way of checking back the sample to see if all of the sulphur dioxide has been absorbed. The apparent volume of the gas measured is also uncertain, due to difficulty in maintaining constant temperature and pressure conditions. Further, even the calculation of the percentage of sulphur dioxide is based upon the use of empirical factors which may or may not apply to the conditions of the analysis. The direct method for the determination of sulphur dioxide, as well as all other chemical gases, such as chlorine, hydrochloric acid gas, oxygen, carbon monoxide and others is not open to the above objection, but on the other hand, is rapid, accurate and reliable.

With the instrument illustrated in Fig. 1, an accurate determination of the percentage of any of the above gases may be made easily in less than five minutes, including the time required for taking the sample.

This is a modification of the Orsat, combining the many good qualities of this instrument with the elimination of its faults. Its manipulation is simple and easily mastered, even by those not experienced in chemical laboratory work. It is portable and self-contained, easily carried to any part of the plant.

To make an analysis, it is only necessary to set or hang up the instrument near the source of supply of gas to be tested and connect sample tube, after which a measured volume of 100 cc. of sample is taken into the instrument when, by raising the leveling bottle, the sample is passed through the absorbing solution in the special bubbling pipette, after which the unabsorbed residue is returned to the burette and measured. The percentage of gas absorbed is read off directly on the graduated measuring burette. The operation may be repeated and if the reading is found to be constant, completeness of absorption is certain.

In the proper regulation of sulphur burners, a determination of the amount of air or oxygen in the

combustion gases is most important. The same instrument is used for the determination of oxygen in the damper regulation, as well as for the detection of air leaks in the line.

In addition to the many advantages of simplicity, accuracy and rapidity, the Williams improved gas apparatus has the widest possible range of adaptability. The same instrument may be used for flue-gas analysis in the boiler room, the determination of sulphur dioxide, chlorine, hydrochloric acid and other corrosive

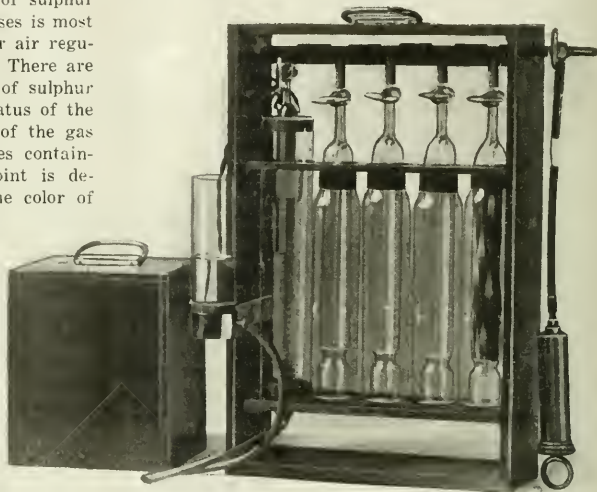


FIG. 1.—WILLIAMS GAS ANALYSIS APPARATUS

gases, as well as for the complete analysis of combustible, illuminating and fuel gases.

### Gas Analysis With Very Small Quantities

An apparatus is described by means of which very small quantities of gaseous mixtures may be analyzed, and in which, during the analysis, the gas comes in contact only with glass, platinum, and mercury. The gas is freed from moisture and carbon dioxide by cooling with a mixture of solid carbon dioxide and alcohol and with liquid air respectively, then burnt by means of a platinum spiral, after addition of oxygen or of hydrogen if necessary; excess of unburnt oxygen is determined by adding hydrogen and again burning, the use of an iron spiral having proved unsatisfactory. A capillary tube is used for the combustion, and if this be effected at a low pressure combination of nitrogen and oxygen and of oxygen and mercury vapor may occur and lead to incorrect results. The use of automatic pumps of the Sprengel type for transferring the gas from one part of the apparatus to another is also inadmissible, as gas occluded by the mercury is liberated when the pressure falls very low and may pass into the measuring tube. The use of Töpler pumps overcomes this difficulty. Results obtained with quantities of gas of the order of 10 cu.mm. are given. In the case of a mixture of  $H_2$ , 26.7, CO 22.7,  $CH_4$ , 22.9, and  $N_2$ , 27 per cent, the values found were  $H_2$ , 26.4, CO 21.1,  $CH_4$ , 24.2, and  $N_2$ , 28.3 per cent.—*Z. anal. Chem.*

## Program of Fourth National Exposition of Chemical Industries

Grand Central Palace, New York  
Week of Sept. 23, 1918

The addresses comprise a series of symposiums devoted to a consideration of

THE DEVELOPMENT OF CHEMICAL INDUSTRIES IN THE  
UNITED STATES, NOTABLY SINCE JULY, 1914.

Wednesday, September 25th.

Afternoon (2:30 P.M.) Symposium: POTASH.

C. A. HIGGINS (Hercules Powder Co.), Recovery of Potash from Kelp.

LINN BRADLEY (Research Corporation), Recovery of Potash from Iron Blast Furnaces and Cement Kilns by Electrical Precipitation.

JOHN W. HORNSEY, Potash from Desert Lakes and Alunite.

ALFRED DE ROPP, JR. (American Trona Co.), Potash from Searles Lake.

Evening (8 P.M.) Motion Pictures.

Electrical Precipitation of Potash from Cement Dust (Research Corporation).

\*Colloid Chemistry.

The Operation of a By-Products Coke Plant (2 reels). (H. Koppers Co.)

Moving a Forest to France (4 reels). (Southern Pine Association.)

The Story of Potash—Production at Searles Lake.

Thursday, September 26th.

Afternoon (2:30 P.M.) Meeting: AMERICAN CERAMIC SOCIETY—Chairman, L. E. Barringer.

L. E. BARRINGER—Manufacture of Electrical Porcelain (Illustrated, Motion Picture).

A. V. BLEININGER—Recent Developments in the Ceramic Industries.

H. RIES—American Clays.

F. A. WHITAKER—Manufacture of Stoneware (Illustrated, Slides).

J. B. SHAW—Fuel Conservation.

S. C. LINBARGER—Carborundum Refractories.

These will be followed by motion pictures as designated for the evening program.

Evening (8 P.M.) Motion Pictures.

THE CERAMIC INDUSTRIES

Glass Making (Corning Glass Co.)

†The Making of Cut Glass.

Manufacture of Electrical Porcelain (General Electric Co.).

†The Making of Pottery.

(9 P.M.) Speakers:

J. A. SWITZER (University of Tennessee), Waterpower Potentialities of East Tennessee.

HERBERT C. HENEGAR (American Zinc Co.), Mineral Resources of East Tennessee.

## From A to Z with the Exhibitors

IN THIS and succeeding daily issues of CHEMICAL & METALLURGICAL ENGINEERING published during the Chemical Exposition will be found brief descriptions of more than 300 exhibits. In order that the record might show the progress that has been made since we entered the war, we have asked the exhibitors to inform us which of their products have been made in this country for the first time since the war began. At the exposition itself the visitor will notice many chemical products marked with a bull's-eye as the distinguishing mark of such progress.

PAUL O. ABBE: Single specimen, assay and jar mills, direct-connected to motors. Duodecuple assay mill, improved rotary cutter, hammer mill, and pony mixer. In charge of exhibit: Mr. ABBE, Miss LAMA.

ABBE ENGINEERING CO.: Patented pulverizing and grinding machinery; laboratory grinding mills; rotary cutters. Special laboratory mills for pulverizing chemicals have been developed since we entered the war. In charge of exhibit: H. F. KLEINFELDT, H. C. RUSS, W. S. RANSOM.

AMERICAN BLAUGAS CORPORATION: Blaugas for operation of laboratory gas appliances and for industrial heating purposes. Dri-Gas for welding, cutting, and brazing. The latter is a new product since the United States entered the war. In charge of exhibit: G. E. BEVES, T. F. HINTZE.

AMERICAN CERAMIC SOCIETY: Charts showing in simplest possible form the size and importance of the ceramic industries both in themselves and in relation to other well known industries.

AMERICAN CHEMICAL & MFG. Co.: Chemical oils, lacquer, technical coatings, acid-proofing and water-proofing, protective coatings for airplanes, submarines, auto-cars, steel cars, steel construction, etc. The new developments since we entered the war are coatings for concrete ship bottoms; anti-fouling ship-bottom paint; pyroxilin coatings for airplanes. In charge of exhibit: W. M. VAN OSTROM, CHAS. D. STILLMAN, F. E. SINCERE, R. C. DEDERICK, E. K. CHAFFEY, F. K. LOCKHART.

AMERICAN CYANAMID CO.: A complete set of cyanamid products: cyanamid, aqua ammonia, nitric acid, ammonium nitrate, sulphate of ammonia, ammo-phos, urea, dicyandiamid, cyanide and Florida pebble phosphate. Cyanamid is the only one of these products produced prior to the war; all others have been developed since 1914. A series of samples will show the steps in the manufacture of cyanamid. Urea is a product that has come into considerable prominence on account of its use as an acid absorbent in nitrocellulose and lacquer used on the fabric of aeroplane wings. Its presence in the dope neutralizes the slight traces of nitric acid that slowly develop and which would otherwise attack and weaken the fabric. Photographs and charts will complete the exhibit. In charge of exhibit: E. J. PRANKE.

AMERICAN ELECTROCHEMICAL SOCIETY. Heavy Browning machine gun in the manufacture of which artificial abrasives are used for between sixty and seventy grinding operations, chrome-carbon alloy steel, manufactured in the electric furnace, is used for the barrel; 8-in. army shell and 6-in. shell, trench hat.







list of processes used extensively in modern warfare; collection of products of electrolytic cell and of the electric furnace, together with photographs of waterpower devices. In charge of exhibit: CARL G. SCHLUEDEBERG.

AMERICAN ANILINE PRODUCTS, INC. A practical exhibit of dyestuffs.

AMERICAN KRON SCALE Co.: Kron automatic dial scale, 1000 lb. capacity, with platform 46 x 36 in., equipped with tare beam for automatic deduction of tare weight. In charge of exhibit: E. OHNELL.

AMERICAN-LA FRANCE FIRE ENGINE Co., INC.: Respirators for protection against dust and fumes. Filter masks for various dust and poisonous fumes. The latter article is a new development following somewhat the idea of the army trench mask.

THE AMERICAN METAL COMPANY, LTD. The following products will be exhibited: Arsenic oxide, coal, copper, copper sulphate, ferroalloys, gold, lead and antimonial lead, molybdenite, muriatic acid, pyrites, salt cake, silver, spelter, sulphuric acid, tin, tungsten concentrates, zinc dust, oxide and sulphate. A special feature is the production of molybdenum concentrates on a large scale. In charge of exhibit: H. M. BURKEY.

AMERICAN METER Co.: Apparatus appertaining to the correct measurement and testing of gas, including calorimeters, siphon gages, sulphur tests, wet test meters, diaphragm dry meters, iron case meters, Tobey meters. The central feature of the exhibit is the calorimeter. In charge of exhibit: ERNEST KERSTEIN.

AMERICAN PIPE BENDING MACHINE Co.: "Wonder" pipe bending machines in two models. In charge of exhibit: E. T. BLAKE, GEO. W. GRAHAM.

AMERICAN WATER SOFTENER Co.: "Delcalso" zeolitic water softener. Glass apparatus will be in operation in which interested persons can soften any samples of water which they may bring with them. This device has been developed and brought out, since we entered the war. In charge of exhibit: R. W. CONRAD.

ANILINE DYES AND CHEMICALS, INC.: Dyestuffs, intermediates and chemicals which are the products of the company's various factories. Many of the dyes and intermediates have been developed since 1914. In charge of exhibits: W. H. VAN WINCKEL.

APEX CHEMICAL Co., INC.: Chemical products used in the textile, leather and allied industries. Since the United States entered the war this company has produced the following chemicals: antimonelle, a substitute for tartar emetic; orthophene, for freeing lime from hides; lactic and formic acids. In charge of exhibit: Dr. S. M. HERMANN, HUGO HELBURN, CHARLES D. RASENBERGER, NELSON CRAIG.

ARKELL SAFETY BAG Co.: "Arksafe" elastic paper lining for barrels, drums, boxes and bags. These linings prevent the sifting of powdered materials from packages and keep the contents clean and dry. In charge of exhibit: C. J. MORALES.

ARNOLD HOFFMAN & Co., INC.: Joint exhibit with Mathieson Alkali Works, Inc., and Nitrogen Products Company. Exhibit of bleaching powders, liquid chlorine, caustic soda, soda ash, sodium bicarbonate and modified sodas, sodium cyanide, red and yellow prussiate of soda and anhydrous ammonia. Pigment colors, gums, dextrine, oils, softeners and textile finishing materials. In charge of exhibit: A. L. HAYES.

BARIO METAL CORP.: Bario metals used in some cases as a substitute for platinum. Electric resistance furnaces. Both the metal and the furnace have been developed since we entered the war. In charge of exhibit: PAUL DEMILES.

BAYONNE CASTING Co.: Monel-metal castings, nickel castings and hot-rolled monel-metal rod. Fabricated monel-metal shapes. In charge of exhibit: H. F. CHASE.

BAUSCH & LOMB OPTICAL Co. A complete photomicrographic outfit for metallographic work, suitable for work with high magnifications; a complete compound metallurgical microscope and smaller accessories. In charge of exhibition: R. C. DEAN.

BEACH-RUSS Co.: Patented rotary high-vacuum pumps, rotary pressure blowers. Extra high-vacuum pumps for chemical plants have been developed since we entered the war. In charge of exhibit: H. C. RUSS, A. T. BEACH, C. A. BEACH.

CHRISTIAN BECKER, INC.: Becker analytical balances, including chainomatic analytical balance and chainomatic specific gravity balance. Torsion balances. The chainomatic balances are new developments since we entered the war. In charge of exhibits: S. W. HESS, Miss C. L. BECKER, A. T. MILLROY.

BECKLEY PERFORATING Co.: Perforated metal products and miniature reproductions of tanks and special shapes in sheet metal which have been furnished to various chemical industries. Tanks and special shapes are electrically welded. In charge of exhibit: ALLEN L. PRICE.

BETHLEHEM FOUNDRY & MACHINE Co.: Castings made of corrosion. It has been necessary for the present to discontinue the manufacture of tantiron castings owing to shipping difficulties. New developments since the war began have been along the line of confidential work for clients. In charge of exhibit: J. GEORGE LEHMAN, R. E. WILBUR, GEORGE ETTLE.

BOYER OIL Co., INC.: Oils and fats, including castor, cocoanut, corn, cottonseed, cod, linseed, mustard, olive, palm, peanut, rapeseed, sesame, soyabean, walnut and whale oils. In charge of exhibit: Mr. KIENLE.

BRISTOL Co.: Recording and indicating instruments for pressure, temperature and electricity.

BUTTERWORTH-JUDSON CORP.: Dyestuffs, intermediates, heavy acids, salt cake, nitre cake, lithopone.

A. M. BYERS Co.: Genuine wrought iron pipe, showing the method of marking every length with name and year of manufacture. Samples of pipe taken from service in an effort to determine relative life of iron and steel pipe. In charge of exhibit: R. W. KENNEY, N. BOLAND.

JOHN CAMPBELL Co.: Aniline colors and coal tar products. Since the United States entered the war this company has produced a full line of direct, basic chrome, acid and sulphur colors sold under trademarked American names. The line is being constantly enlarged. In charge of exhibit: GEORGE H. WHALEY.

CANADA CARBIDE Co., LTD.: Samples of domestic and export sizes of carbide; domestic and export packages; projection lantern and colored slide. In charge of exhibit: H. E. MUSSETT.

CANADIAN CHEMICAL JOURNAL: A representative will be in charge to give information on Canada, statistics

of Canadian products, especially those relating to the chemical and metallurgical industries. In charge of exhibits: E. B. BIGGAR, L. E. WESTMAN.

**CARBORUNDUM CO.:** Carborundum protection pyrometer tubes, carborundum fire sand, silicon metal. Carborundum resistance rods for use as lightning arresters or similar work where a static resistance only is required. Miscellaneous exhibits of small refractories made from silfrax. High grade fire brick, carbofrax and refrax.

**CARRIER ENGINEERING CORP.:** Model Carrier system of air-conditioning in operation. Samples of materials in the manufacture of which the Carrier system plays an important part. In charge of exhibit: J. I. LYLE, E. P. HECKEL, L. L. LEWIS, M. S. SMITH, GEORGE SCHMIDT.

**CELLULOID ZAPON COMPANY.** Lacquer enamels and varnishes, bronze liquids, amyl acetate, soluble cotton.

**CENTRAL DYESTUFF & CHEMICAL CO.** Coal-tar colors and intermediates. In charge of exhibit: M. UNDERLEIDER, A. F. WIEHL, E. MONTALENT.

**CENTRAL SCIENTIFIC CO.:** Laboratory specialists; de Khotinsky constant temperature apparatus, Parr Calorimeters; balances and weights; electrical instruments. Since the United States entered the war the company has produced special analytical balances, vacuum pumps, stills and rotary blowers. In charge of exhibit: S. L. REDMAN.

**CHEMICAL CO. OF AMERICA, INC.:** Intermediates for dyestuff manufacture, in addition to which will be featured a khaki color. In charge of exhibit: Messrs. KENDALL and CHRIST.

**CHEMICAL CONSTRUCTION CO.:** Blueprints showing the installation of different kinds of acid plants constructed by the company. A model acid-proof masonry tower showing detailed interior construction. Samples of acid-proof brick and acid-proof cement joints. The acid-proof masonry has played an important part in the construction of government nitrate plants throughout the country. The spiral chemical packing rings for use in absorption towers have been produced in excess of 100,000,000 this year. In charge of exhibit: R. L. RUTZLER, T. C. OLIVER.

**CHEMICAL WARFARE SERVICE, NATIONAL ARMY:** Information bureau regarding industrial relations and university relations. Exhibit of gas masks by Gas Defense Division. Exhibit of Gas Offense and Research Divisions. In charge of exhibit: Maj. F. E. BREITHUT.

**CLINCHFIELD PRODUCTS CORPORATION:** Full line of products, including sodium sulphide, barium carbonate, barium chloride, barium sulphate, barium sulphide, Glauber's salts, and ground feldspar. In charge of exhibit: J. G. HARRIS.

**CRANE CO.:** A line of valves, fittings, and specialties for steam-power, heating and process work and for water, gas, and chemical purposes. The feature of the exhibit will be a complete steam plant in actual operation, demonstrating the company's products but particularly the boiler-feeding system. In charge of exhibit: W. L. OSWALD, WM. FINK.

**CRANE PACKING CO.:** "John Crane" babbitt foil metallic packing, which is made of very thin sheets of babbitt foil, spirally wound to allow of the greatest amount of compression and flexibility. This material

is specially applicable to use in the chemical industry. Centrifugal water-pump sets of packing will be shown, and asbestos copper foil wrapped packing for superheated service. In charge of exhibit: F. E. PAYNE, JULIAN N. WALTON.

**CRESCENT COLOR & CHEMICAL WORKS, INC.:** An exhibit of dry and pulp colors. In charge of exhibit: N. A. MCMAUS, JAMES MURRAY, JOHN GLEDHILL, V. J. CHARTRAND.

**CRESCENT INK & COLOR CO., INC.:** An exhibit of the manufacture of ink. In charge of exhibit: N. A. MCMAUS, JOSEPH M. PETRY, WALTER A. CONLAN.

**CROMOS CHEMICAL CO., INC.:** A display of benzoic acid, benzoate of soda and benzyl chloride. In charge of exhibit: I. MARK, J. H. LYONS.

**J. H. DAY CO.:** Mixing machines for handling powders, liquids, and pasty materials. In charge of exhibit: R. W. WALLACE.

**DENVER FIRE CLAY CO.:** Laboratory and plant specialties including furnaces, crushers, samplers, screens, fire-clay products, electroscope equipment for testing radioactivity, oil and gas burners. In charge of exhibit: J. S. KING, E. R. HARRIS.

**DETROIT RANGE BOILER CO.:** "Perfect" metal bilge barrel and drum, used as steel containers in the chemical industry. The tight barrel is suitable for handling liquids. The removable-head barrel can be used for powders, semi-solids, heavy liquids, and other products the emptying of which requires the entire head to be taken out of the barrel. In charge of exhibit: W. B. GOGGARD.

**J. P. DEVINE CO.:** Vacuum drying chambers of several sizes made up in complete installation form, with all necessary fittings, mountings and auxiliaries, a condenser and a rotary valve vacuum pump; a high-pressure cast steel autoclave; copper distilled-water outfits capable of delivering 5 gallons of pure distilled water per hour; a double-effect vacuum evaporator suited for the experimental and research laboratory; some chemical equipment and a display of photographs. In charge of exhibit: J. P. DEVINE, NATHAN OWITZ, L. W. TREICHLER, A. D. RENNER, A. M. FRANTZ, E. H. MILLER.

**DIAMOND STATE FIBRE CO.:** Diamond fibre products including receptacles for mills, fibre sheets, rods, and tubes employed in the electrical industry. Features developed since the war are red spinning parchment, Diamond-F food-protective papers. In charge of exhibit: T. M. BOGERT.

**DORR CO.:** The Dorr agitator, Dorr bowl classifier, Dorr tray thickener, and Dorco pump in closed circuit, demonstrating their various functions in a number of different chemical processes. A pulp containing different materials will be mixed in the agitator, separated in the classifier, thickened and dewatered in the thickener, and handled by means of the pump. This equipment has recently entered into the construction of several explosive plants built for the Government. In charge of exhibit: H. N. SPICER.

**DYE PRODUCTS AND CHEMICAL CO., INC.:** A display of dyestuffs and intermediates used for the manufacture of khaki dyestuffs for U. S. Government uniforms showing the various steps necessary in the manufacture of these materials. In charge of exhibit: SIDNEY SIMON, L. M. LOWENTHAL, CLARENCE K. SIMON.

## Development in Nitric Acid Manufacture in the United States Since 1914\*

Nine-Fold Increase in Production Since War Began—Ammonia Oxidation Process May Be Greatest Source of Production After the War—Data on Catalyzer Efficiency

By E. J. PRANKE

THE production of nitric acid in 1914, according to the census of manufacturers, was 78,589 tons of nitric acid of average strength, and 112,124 tons of mixed acid. According to other data given in the census, these figures represent about 89,000 tons of 100 per cent nitric acid. All of this acid was produced from nitrate of soda, consuming about 160,000 tons of nitrate. The pre-war importation of nitrate of soda amounted to about 560,000 tons per annum; hence the normal consumption for purposes other than the manufacture of nitric acid was about 400,000 tons.

The present rate of importation is about 1,600,000 tons of nitrate per annum. Since very little is going into storage and the total consumption for purposes other than nitric acid manufacture has increased but slightly, if at all, it may be estimated that at least 1,000,000 tons of nitrate per annum is being converted into nitric acid at the present time. This is equivalent to 650,000 tons of 100 per cent nitric acid, of which nearly five-sixths is being used for the manufacture of military explosives.

### IMPROVEMENTS IN RECENTLY BUILT PLANTS

The building of the new nitrates of soda acid plants has offered an excellent opportunity for the introduction of many improvements. The Dutch ovens under the retorts have been displaced by modern fire-boxes provided with a proper arch. This change has effected a saving in coal consumption of approximately 25 per cent. The chemical stoneware from the retorts to the condensers and the glass condenser tubes have been displaced by acid-proof, high-silica iron, such as duri-iron and tantiron. The volvic-ware saucers in the towers have also been displaced by acid-proof iron. The chemical ware from the condensers to the absorption towers, and the glass lines for circulation of acid at the sides and top of the towers, however, are retained. The absorption tower capacity has been increased about 40 per cent by the addition of more towers. Spiral rings for tower packing have taken the place of the ordinary form of packing.

Important changes have also been made in operation. The average charge of 5000 pounds of nitrate per retort has been increased to about 7500 pounds. The retorts, instead of being operated in batches, are now operated in rotation. Instead of three runs per retort per day, the usual practice is now two runs per day. Temperatures are also controlled more carefully than in the past.

The result of these improvements is an increase in the amount of nitrogen recovered as acid from an aver-

age of from about 78 to 80 per cent to about 92 to 94 per cent of the nitrogen in the nitrate of soda. At the same time the labor requirement has been somewhat decreased.

A good beginning has also been made in the recovery of nitroso gases produced in the various nitration operations. In some of the systems that have been devised, as much as one-half of the fumes are being recovered. The collection of the gases from the many nitration units, however, is still a serious problem. While the aggregate amount of acid that is being recovered is large, it represents only a small fraction of the acid gases that are being wasted. In the ordinary nitration operation as carried out at present, about one-tenth or one-twelfth of the nitric acid is wasted in the wash waters, while on an average about one-eighth is lost as fumes, of which one-half is recovered in plants equipped with recovery systems.

Nitric acid by direct combustion of air by the arc process has not had any important development as yet in America. Three small plants, more or less on an experimental scale, have been built in the United States and operated for short periods. The production of these plants thus far has been negligible. The total annual capacity probably does not exceed two or three thousand tons of nitric acid per annum.

Nitric acid by the oxidation of ammonia has received a considerable and important development since the outbreak of the war. In 1914 there were no ammonia oxidation plants in this country. At the present time there are under construction ammonia oxidation plants with a capacity equal to about 225,000 tons of 100 per cent nitric acid per annum.

### DEVELOPMENT OF AMMONIA-OXIDATION PLANTS

The first commercial-sized oxidation plant was established in July, 1916, at the Ammo-Phos Works of the American Cyanamid Company at Warners, New Jersey. Six catalyzer units were installed, each with a presumed capacity of 14 pounds nitric acid per hour. Improvements in the design of the catalyzer and in methods of operation have brought the capacity to over 40 pounds of nitric acid per hour. The catalyzer used is a single fine platinum gauze, with an area of about two square feet, electrically heated. Over a period of two years two of these units have supplied the nitric requirements of the 60,000-ton sulphuric acid chamber plant at this works. The ammonia is taken directly from cyanamide autoclaves producing about 30 tons of ammonia gas per day, used mainly for aqua ammonia manufacture. This plant has served for several months as a training school for the instruction of operatives for the Government cyanamide-nitrates plants. As an

\* A paper read at the Fourth National Exposition of Chemical Industries, New York, Sept. 24, 1918.



example of the normal operation of the catalyzers on ammonia taken directly from the autoclave mains, Table 1 is quoted verbatim from the records for the week July 13 to 19, 1918. Each value is the average of determinations of two chemists working independently, with the exception of those marked (\*) which are determinations of one chemist only.

TABLE 1.—EFFICIENCY OF CATALYZERS IN AMMONIA OXIDATION

| Catalyzer No. 5      |            |            | Catalyzer No. 6      |            |            |
|----------------------|------------|------------|----------------------|------------|------------|
| Date                 | Time       | Efficiency | Date                 | Time       | Efficiency |
| July 13              | 2.35 a.m.  | 96.2       | July 13              | 5.30 a.m.  | 96.0       |
|                      | 8.40 a.m.  | 98.5       |                      | 1.10 p.m.  | 93.0       |
|                      | 5.20 p.m.  | 92.1       |                      | 8.40 p.m.  | 93.4       |
| " 14                 | 11.50 p.m. | 96.0       | " 14                 | 2.50 a.m.  | 93.0       |
|                      | 5.50 a.m.  | 97.4       |                      | 1.00 p.m.  | 94.2       |
|                      | 5.10 p.m.  | 94.8       |                      | 10.15 p.m. | 93.2       |
| " 15                 | 10.35 a.m. | 95.0       | " 15                 | 1.5 a.m.   | 95.6       |
|                      | 5.15 p.m.  | 95.8       |                      | 2.20 p.m.  | 90.7       |
|                      | 1.50 a.m.  | 95.4       |                      | 11.30 p.m. | 92.6       |
| " 16                 | 11.20 a.m. | 95.4       | " 16                 | 8.00 a.m.  | 96.0       |
|                      | 1.70 a.m.  | 92.1       |                      | 8.25 p.m.  | 92.0*      |
|                      | 1.00 p.m.  | 92.2       |                      | 7.50 a.m.  | 90.9       |
| " 17                 | 12.50 a.m. | 93.1       | " 17                 | 8.20 p.m.  | 94.0       |
|                      | 10.55 a.m. | 92.6       |                      | 7.40 a.m.  | 92.0       |
|                      | 8.00 p.m.  | 91.9       |                      | 5.10 p.m.  | 91.6*      |
| " 19                 | 9.50 a.m.  | 93.6       | " 19                 | 4.15 a.m.  | 95.0       |
|                      |            |            |                      |            |            |
| Average for the week |            | 94.5       | Average for the week |            | 92.5       |

#### MUSCLE SHOALS PLANT IN OPERATION NOVEMBER FIRST

The cyanamide-nitrates plant at Muscle Shoals, Alabama, will use the electrically heated single-gauze catalyzer. It will produce approximately 90,000 tons of 100 per cent nitric acid per annum. The plant is expected to go into operation about November 1. The cyanamide-nitrates plant near Cincinnati, and the one near Toledo, Ohio, will also use the same process, each producing at one-half the above rate. They are expected to be in operation early next spring.

The Government experimental plant at Sheffield, Alabama, known as Nitrate Plant No. 1, which will make about 15,000 tons of nitric acid per annum, has adopted a non-electrically heated multiple screen, consisting of several layers of platinum gauze, welded together at points, and rolled into the form of a cylinder. The ammonia-air mixture flows outward through the screen at a rate several times as fast as with the electrically heated single screen. After the oxidation has been started by external application of heat the temperature is self-sustaining from the heat of reaction.

#### NEGLECTIBLE CONSUMPTION OF ELECTRIC ENERGY

In view of the perfect control obtainable with electrical heating, the cost of the electric energy consumed, amounting to about one-third of one per cent of the present market value of the nitric acid, may be regarded as negligible. As to the single versus the multiple screen the efficiencies cited above as examples of normal operation of electrically heated single screens are believed to represent the highest standards yet attained in the practical operation of ammonia catalyzers.

It is understood that the Semet Solvay Company has an ammonia oxidation plant at Syracuse, New York, using the multiple screen without electrical heating. This plant is producing several tons  $\text{NaNO}_3$  per day. Information regarding efficiencies is not available.

In addition to the plants above mentioned, the Navy Department decided about two months ago to build a plant at Indian Head, Maryland, for fixing nitrogen by the modified Haber Process used at Plant No. 1. All the ammonia produced will be oxidized to nitric acid, yielding about 30,000 tons per annum.

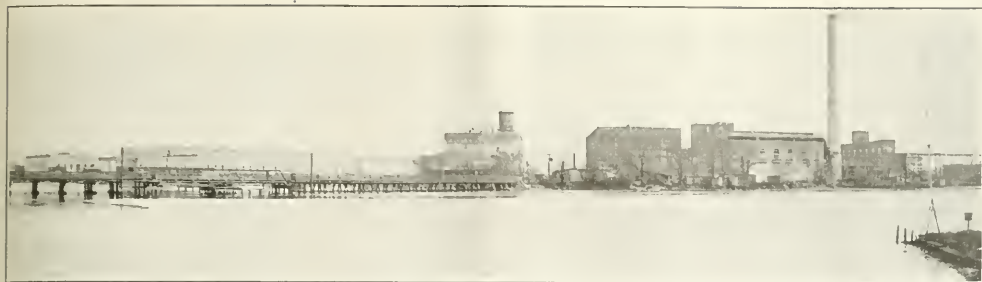
Considerable work is also being done on the use of catalyzers to hasten the conversion of the nitrose gases, obtained from the catalyzers, into nitric acid. The object is to reduce the amount of space required for reaction chambers. The experiments along this line show promise of early success.

#### PRODUCTION NEXT SPRING WILL BE NINE TIMES NORMAL

The nitric acid producing rate in the spring of 1919 will be about 650,000 tons from nitrate of soda and about 225,000 tons by oxidation of ammonia obtained from the air, a total of \$75,000 tons of 100 per cent nitric acid. This is about nine times the pre-war normal consumption. In 1914 the industrial explosives industry consumed about 50,000 tons per annum, while all other uses took only about 40,000 tons. The only notable increase in consuming ability since 1914, aside from military explosives, has been in the dye industry. In 1917 it was estimated that 30,000 tons of dyes were produced in America, equal to the total 1914 consumption. The production will probably increase somewhat further, but at most could hardly consume more than 30,000 or 40,000 tons of concentrated nitric acid. With a producing rate of \$75,000 tons, and a consuming ability in peace times of 125,000 tons, or possibly 150,000 tons, it is evident that over four-fifths of the nitric acid producing capacity will have to be shut down as soon as peace conditions are established.

#### AMMONIA-OXIDATION METHOD MAY BE PRINCIPAL SOURCE

The successful development of the ammonia oxidation process raises the question whether this may not become the principal source of nitric acid in the future. While a categorical statement cannot be made, some of the major factors may at least be pointed out. The cost of converting nitrate of soda to concentrated nitric acid is just about equal to the cost of converting autoclave ammonia gas to concentrated nitric acid, interest and depreciation included in both cases. Ammonia gas, however, is a cheaper form of nitrogen than is nitrate of soda. It is cheaper by the amount of sulphuric acid required to fix the ammonia gas in the form of sulphate of ammonia. For nitrate of soda and sulphate of ammonia in the past have always sold at about the same price per pound of nitrogen. They will probably be sold on a competitive basis after the war, or if there is any difference the ammonium form will probably be the cheaper. The differential between ammonia gas and sulphate of ammonia, then, will make a difference of about 15 to 20 per cent in the cost of nitric acid in favor of ammonia oxidation. The fact that the nitrate of soda acid plants are being amortized during the war and are conveniently located for peace-time industrial uses, while new ammonia oxidation plants would have to be built at these same points in order to avoid transporting acid, is relatively not very important, because the interest and depreciation charge saved by amortization of the nitrate of soda acid plants is only about 4 per cent of the normal cost of the acid. The decisive factor will probably be simply the question whether the difference in cost of acid by the two processes is a sufficient incentive to overcome the inertia of human nature against changing existing practices.



## Industrial Developments Relating to the Manufacture of Acetic Acid and Acetone

**Tremendous Demand for Acetone for Explosives Led to Its Production from Molasses, Alcohol and from Calcium Carbide—Wood-Distillation Industry Faces Disaster Unless It Develops Scientifically**

BY HAROLD HIBBERT

Director Research and Technical Division,  
Ralph L. Fuller & Co., Inc.

PRIOR to 1914, more than half the entire world's supply of acetone and acetic acid was furnished through the medium of the wood-distillation industries of this country and Canada, the remainder being contributed principally by Austria-Hungary. When wood is heated in closed iron retorts in absence of air, it undergoes a decomposition whereby certain volatile constituents such as acetic acid, acetone and methyl acetate are driven off, the residue consisting of wood charcoal. In practice the crude acetic acid is neutralized by the addition of lime, which is then converted either into refined acetic acid or into acetone.

Acetic acid is used very extensively in the chemical industry for the manufacture of dyestuffs, pharmaceutical preparations, varnish for aeroplane wings and also as a condiment, while acetone finds its main outlet as a general solvent for varnish, lacquers, and in the manufacture of explosives such as cordite. This latter is used in immense quantities by the British and other Navies, and is made from a mixture of gun cotton with nitroglycerine. In order to "compound" these materials, that is, to enable the gun cotton to become thoroughly incorporated with the nitroglycerine, it is necessary to employ a solvent which in this case happens to be acetone. Many other solvents have been tried out, but this has been found to give the best results. The British Admiralty early foresaw the necessity of obtaining large supplies of this material, and a few months after war broke out they were endeavoring to contract for an immediate supply of approximately 15,000 to 20,000 tons. This amount was considerably more than the entire world's annual production.

According to an article by Messrs. French & Withrow<sup>1</sup>, the annual production of grey acetate of lime in this country in 1914 amounted to approximately 84,000 tons, since increased in 1917 to over 100,000 tons. This is equivalent to about 17,000 tons of acetone if all of it were employed for this purpose. As a matter of

fact the greater part was used for the manufacture of acetic acid, the output of acetone being in the neighborhood of 7500 to 8000 tons annually. Faced with a sudden demand for an immediate increase in this commodity to some 20,000 tons, it was evident that new measures would have to be adopted for its manufacture, since it was altogether impossible to obtain this amount from the wood-distillation industry in the short time available. The assistance of the chemist and chemical engineer were therefore sought, and it is to the credit of the profession that they have provided an eminently satisfactory solution to meet this most urgent demand. The first line of attack was found in an attempt to increase the acetic acid production by the fermentation of various carbohydrate materials, as for example, molasses, through which alcohol and from this acetic acid in turn can be manufactured.

Working in coöperation with the British Government, the U. S. Industrial Chemical Co. has erected a large plant at Curtis Bay, and in spite of the many difficulties encountered both from a chemical, biological and engineering standpoint, they have so far succeeded that they are now manufacturing acetic acid, equivalent to approximately 70,000 pounds of 100 per cent strength per day, which is used for the manufacture of acetone and methyl acetate. This huge amount is all made from vinegar obtained from molasses alcohol by the quick fermentation process.

Some idea of the work involved in such an undertaking may be obtained when it is remarked that it was found necessary to construct special tank steamers for the conveyance of the molasses from Cuba to Baltimore. The generators comprise one series of 200 tanks, 25 ft. by 18 ft., and a second series of 960 of a size of 10 ft. by 18 ft. These are filled with beech shavings through the agency of which the oxidation of the alcohol to acetic acid is effected.

Anyone acquainted with the delicate nature of the changes taking place in such fermentations is well aware of the extraordinary care and oversight which it

is necessary to give to such operations to insure a commercial success, and the fact remains that the plant is now functioning day in and day out with continuous regularity.

To transport the dilute acetic acid liquors to the evaporators requires approximately 35 miles of wooden piping, and the evaporators installed for the concentration of the calcium acetate liquors, which are capable of handling some 200,000 gallons of liquor per day, require for this purpose a power consumption of 3000 horsepower.

While in all probability the manufacture of acetic acid and acetone by this process will not be profitable after the conclusion of peace, there is no doubt but that the company operating this plant will have first claim to be the largest manufacturers of alcohol in the world and the country should be proud of their supremacy in this respect.

#### FERNBACH PROCESS: FERMENTATION OF STARCH

Even with this additional amount of acetone and acetic acid available, it was evident that there would not be sufficient to meet the requirements of the British Government and their Allies, so that other processes came up for discussion. Among these was one relating to the "FERNBACH" process. This consists in the fermentation of starch from corn or other grain by means of a special ferment which has the power of resolving the carbohydrate material into a mixture consisting essentially of butyl alcohol and acetone, the former largely predominating. The conditions of fermentation call for strict, careful chemical and biological control and those responsible for its development are to be congratulated on the successful results obtained. It is understood that the output of acetone at the plant in Toronto now amounts to 100 tons per month, while from the one in this country it approximates close to 250 tons. It would seem that the industrial disposal of the large tonnage of butyl alcohol formed would call for serious consideration, but it should offer no insuperable difficulties to the chemical profession.

Of the other processes calling for consideration, one of the most interesting was that relating to the manufacture of acetic acid from acetylene, regarding which a number of German patents had already been taken out some seven or eight years ago.

It has been known for a considerable period of time that when acetylene gas is passed through a solution of a mercury salt in dilute acid, it combines with the water, yielding a somewhat volatile liquid known as acetaldehyde, from which acetic acid in turn is readily obtained by the action of atmospheric oxygen. While those acquainted with the subject were aware of these developments, and with the fact that a plant had already been in operation in Germany for some two or three years prior to the outbreak of war, it nevertheless came as a great surprise to the majority of those interested that such was in reality the case.

The incident in fact merely furnishes another remarkable instance of the wonderful foresight of the German authorities in providing for their own requirements of such commodities, both from an industrial and especially from a military standpoint. To render themselves independent of this country in the matter of acetate of lime, research work was encouraged both in the universi-

ties and in the industry, and after laborious and painstaking investigations extending over many years, they were in a position to manufacture acetic acid and acetone from naturally occurring materials, namely, lime and coal, both available in large quantities in their own country.

#### SYNTHESIS FROM LIME AND COAL

Apart from a few experiments carried out by the writer while with the duPont Powder Company, nothing had been attempted in this country or Canada. However, the British Government was very fortunate in being able to obtain the hearty coöperation and assistance of the Shawinigan Light & Power Co., a Montreal corporation closely identified with the Canada Carbide Co. This concern on being approached by the British Government agreed to commence work immediately on the scientific aspect of the problem and was ably assisted in this connection by Prof. Ruttan of the McGill University, Montreal, Canada. They were fortunate in obtaining the services of Mr. Howard W. Matheson, formerly of the duPont Powder Co., and it is due to the chemical research investigations carried out by this chemist (ably supported as he was by the engineering skill of the vice-president of the company, Mr. Julian C. Smith) that they were successful within a period of one year not only in completing the experimental work (regarding which they were up to that time in complete ignorance), but also in erecting and starting the plant in actual operation.

The experimental work was started in December, 1915, and the plant was completed and commenced to operate in January, 1917, the total cost being somewhat over two million dollars. The output amounts to 56,000 pounds of 100 per cent acetic acid daily. When it is remembered that new and difficult questions of plant construction had to be faced, special type of construction relating to acid-proof materials and other important problems solved (in fact the creation of quite a new industry in this connection), and also that entirely new methods had to be devised in connection with each stage of the process, such as the electrolytic regeneration of the mercury etc., some idea may be obtained of the immense amount of labor involved. Not only was it necessary to build the chemical plant, but alongside of it a plant for the necessary calcium carbide had also to be erected and put into operation.

#### SECOND PLANT APPROACHING COMPLETION

When this country entered the war the question was discussed as to the advisability of erecting here a similar plant, but in view of the length of time it would take to develop the process and the saving which could be effected by coöperating with the Canadian Electro Products Co., an agreement was entered into for the duplication of the Canadian plant at an expenditure of over two million dollars. This second unit is now rapidly approaching completion and is expected to be in operation about December 1. The two plants will have an approximate production of around 55 tons per day of 100 per cent acetic acid.

The question as to what is to be done with this immense production after the war is one calling for serious consideration, as this is greater than the entire world's consumption. There would seem, however, to be no reason why the cost of manufacture should not



enable them to provide the industry with far cheaper acetic acid than was obtainable prior to 1914, and in this case the consumption will undoubtedly be largely increased in such industries as the manufacture of crude rubber, lacquers, dyestuffs etc. It should also be borne in mind that it is not at all improbable that extensive new industrial outlets will be found for acetaldehyde. This product, as far as its chemical reactivity is concerned may be said to bear the same importance to the so-called "aliphatic" chemical compounds as benzene does to the aromatic derivatives. From it by various chemical processes a whole series of valuable products

practically constant. Recent researches have shown that it is possible to submit the wood tar to a process of distillation and by this means separate out certain of its constituents possessing marked germicidal action. This special property may then be intensified to a remarkable extent by certain simple chemical processes, thus increasing the value materially for purposes such as wood preserving, disinfectants, sheep dips etc.

There would also appear to be no doubt but that certain fractions of wood tar may be used to great advantage in the manufacture of varnish compositions and coatings, similar to the phenol formaldehyde con-



THE CANADIAN ELECTRO PRODUCTS COMPANY

such as glycerine derivatives, solvents for nitro and acetyl cellulose, useful varnishes, camphor substitutes, synthetic rubber and numerous pharmaceutical products can be obtained, the development and exploitation of which will certainly follow on the conclusion of peace.

#### WOOD DISTILLATION INDUSTRY ON THE DEFENSE

It is evident from the above that the wood-distillation industry after the war will have to fight for its existence, as the price of acetone will undoubtedly fall to a low level. In all probability the price of acetic acid made from carbide will be such that it will be impossible for them to compete. There is, however, a "life saver" in the situation in that the industry possesses in acetone, crude acetone oils, and wood tar, a very valuable source of, as yet, undiscovered revenue. If the wood distillation industry will only enlist the services of the industrial chemist, they will find that acetone can be readily and cheaply transformed into valuable solvents for varnishes and nitrocellulose lacquers. Moreover, it can be employed for the manufacture of synthetic rubber and glycerine substitutes, the latter possessing properties comparable to those of the ordinary glycerine of commerce. From the wood tar itself the well-known beechwood creosote can be made, the demand for which is increasing rapidly, while the production has remained

practically constant. Recent researches have shown that it is possible to submit the wood tar to a process of distillation and by this means separate out certain of its constituents possessing marked germicidal action. This special property may then be intensified to a remarkable extent by certain simple chemical processes, thus increasing the value materially for purposes such as wood preserving, disinfectants, sheep dips etc.

There would also appear to be no doubt but that certain fractions of wood tar may be used to great advantage in the manufacture of varnish compositions and coatings, similar to the phenol formaldehyde con-

densation products, while the pitch obtained as a residue when manufactured under certain well defined conditions is found to possess properties rendering it much more valuable than ordinary coal tar pitch for certain insulating purposes. Furthermore, there is a wide field in the application of certain constituents of these oils for use as protective coatings in the lining of acid vats, as extended experiments would seem to indicate that corrosion could best be guarded against in the handling of large quantities of acid liquors of various kinds by the employment of such materials.

#### GERMANY AND SWITZERLAND MAKE ALCOHOL AND ACETIC ACID FROM CALCIUM CARBIDE

Nothing is clearer than the fact that unless the wood distillation industry awakens to the necessity of the employment of the trained research chemist and chemical engineer in the development of their business, the industry faces a very disastrous future. That this is the case is borne out by the fact that both in Germany and in Switzerland large electrical installations have been erected for the manufacture of alcohol and acetic acid from calcium carbide. The one in Switzerland is expected to use a minimum of 20,000 and a maximum of 30,000 hp. and produce annually 7500 tons of alcohol as a minimum and 10,000 as a maximum. It is stated

that this will make Switzerland an exporter instead of an importer of alcohol. The writer is informed by the American Consul in Berne, Switzerland, that the manufacture of acetic acid has already been commenced and that the manufacture of alcohol will be taken up later. In the Swiss Government reports on this subject, attention is drawn to the fact that Switzerland is dependent on this country and Austria-Hungary for its supply of acetate of lime. Government support for this undertaking was obtained with a view to making the country economically independent in this respect.

In Germany, according to the *Chemical Trade Journal*, the quantity of acetic acid produced in 608 vinegar factories amounted in 1913 to about 12,000 tons, while the quantity produced from calcium acetate and wood vinegar amounted to 23,000 tons of anhydrous acid. During the war several large factories for the production of acetate acid from carbide had been completed, while others are in course of construction with a view to the manufacture of artificial rubber. The factories if fully utilized are capable of producing 25,000 tons of acetic acid annually.

Much valuable research work has already been carried out under Government auspices at experimental stations such as the one at Madison, Wisconsin, and if full advantage were taken of these results as well as of the desirable coöperation of the industry, with such well equipped institutions as those at Syracuse, Cornell and Michigan, the future of the industry might be assured. As some of these institutions are supported by State funds, it is difficult to understand why their coöperation should not be sought and in fact insisted upon.

The article by Messrs. French & Withrow, referred to above, gives a very complete historical review and account of present day conditions in the wood distillation industry and contains much valuable food for thought in this connection.

New York City.

### Dyeing With Coal Tar Dyestuffs

By C. M. Whittaker. Pages, 214. Price \$1.80.  
London: Baillière, Tindall & Co.

The author has been in charge of the experimental dye-house of one of the larger British dye manufacturers for a number of years and while he has not undertaken to teach the novice to be a successful dye artist, he has made a great deal of information on this subject more interesting as well as easily capable of assimilation. The point of view throughout the book has been based on the commercial requirements. Basic dyestuffs are described with reasonable detail and the scope of use of this class of colors indicated. Acid dyes, alizarine, direct cotton, azo, resorcin, sulphur, vat, oxidation and compound textile dyes are all treated in a very readable manner.

Mr. Whittaker says, "The ever present demand for cheapness must always be recognized, however much one may regret it. Big production in modern industry takes the form of a cheap, not a dear, article. A constant endeavor is being made by cloth designers to make as good an imitation as possible of a costly fabric of a cheaper material. This explains why one now meets so many fabrics which contain wool and cotton to imitate at a low price the more expensive all-wool article. To give an example, a cotton warp is woven with a woolen weft in a serge pattern to imitate an all-woolen serge. These fabrics have to be dyed, and reflect themselves in the increasing demands for union dyestuffs, which has been one of the most striking features in the modern coal-tar dye industry." The subject of dyehouse machinery is not gone into, the book being intended to supplement the average chemist's training in preparation for textile work.

## The Manufacture of Enamel-Lined Apparatus\*

BY EMERSON P. POSTE

THE field of enameling includes enamels applied to steel and those applied to cast iron. Under the former heading we have cooking ware, signs and other miscellaneous pieces and apparatus used for large-scale food preparation and the chemical industries. Cast iron includes sanitary ware, various stove parts and other decorative pieces and apparatus for chemical and pharmaceutical purposes.

In the preparation of an enamel, various raw materials such as feldspar, borax, soda, cryolite and fluor-spar are used for the basis of the mixture. Various colors are produced by the use of cobalt, manganese and other coloring oxides some of which are added in the original mix and others in the mill.

These raw materials are thoroughly mixed and placed in a hot smelting furnace, where the materials are melted together and drawn out into a tank of water and granulated. The product is called frit. This frit is ground either wet in a pebble mill with water, clay and other mill additions, or ground in a dry mill for application by the dry process.

The steel ware to which the enamel is to be applied is manufactured either by pressing, drawing, spanning or welding. Whatever the manner of preparation or the nature of the piece, the surface to which the enamel is to be applied must be clean. This is accomplished either by pickling or sandblasting, depending upon the size.

The application of the enamel by the dry process on cast iron involves the spraying of a preliminary ground coat which when dry is placed in the furnace and withdrawn at a red heat. The dry powder is dusted on, the piece put back in the furnace, the enamel melted down, the piece withdrawn, more enamel added, and so on until a sufficient coat is built up.

In the wet process the enamel after drawing from the wet mill is treated with electrolytes to make a proper consistency for spraying or other method of application. The piece is then either dipped in the enamel, the enamel poured over or sprayed on, depending upon the size and shape of the piece.

In the burning of the ware two general types of furnaces are used, direct-fire and muffle. The latter is more general in connection with cooking ware and smaller pieces while the former is used on some of the larger pieces used for chemical work and large-scale food preparation. In either case the burning of the enamel consists in melting down the individual particles and fusing them together in the form of a continuous coating.

Apparatus made in accordance with the above general outline ranges from 50-gallon to 4500-gallon units in steel and from 2-gallon to 300-gallon in cast iron. The former line finds application primarily in the dairy, canning and other food industries. Units are also used as storage, evaporating and reaction tanks for chemical processes of a neutral or slightly acid nature. The cast iron equipment is used as above and in addition for the most severe chemical conditions involving mineral acids.

\*An abstract of a paper read at the Fourth National Exposition of Chemical Industries, New York, Sept. 24, 1918. The paper was illustrated by lantern slides, and there was an exhibit of products.



# American Dyes from a Manufacturing Standpoint

Domestic Dyestuff Industry Becoming an Accomplished Fact—Analysis of Our Needs and Figures of Actual Production—Permanence of Industry Depends on Tariff

By W. H. WATKINS

THE developments growing out of the Great War made it evident by the Spring of 1915 that we should be obliged to look to ourselves for our accustomed supply of dyestuffs. There was no question of going without them. The great textile, leather, paper and other industries were in great part dependent upon dyes for the production of merchantable goods. Natural dyestuffs found in part fill the gap caused by the elimination of Germany as a source of supply of coal-tar dyes; but natural dyestuffs could not be obtained in sufficient quantity, nor were they in many cases acceptable substitutes either by reason of lack of fastness or variety of hue, or because of difficulty of application. If the textile, paper, leather and other industries giving employment to perhaps two million people and producing goods of a value of perhaps four billion dollars were to continue doing "business as usual" an American coal-tar dyestuff industry had to be created.

To the chemist the outlook was most enticing. What could be finer than the opportunity for working out methods for the manufacture of hundreds, perhaps thousands of beautiful compounds, beautiful to the chemical sense as well as to the eye. The manufacturer, chemist or not, who contemplated engaging in this industry however, could not consider alone the alluring chemical side of the problem. American chemists had always found this coal-tar chemical industry a most interesting industry to look at and talk about, but also had generally concluded that it was a very safe industry to let alone. The few chemists or manufacturers who did take hold of it were generally found after a few months, or a year or two, vigorously blowing their fingers.

## FIGURES AND STATISTICS NOT ALLURING

So it was well for the manufacturer who felt the lure of coal-tar dyes or chemicals to look over the chemical charts before embarking on the deep waters of their manufacture. The most recent charts available in the spring of 1915 were not particularly encouraging. An eminent ex-president of the American Chemical Society had demonstrated to the United States Chamber of Commerce that it was distinctly a "one-nation" business. He made a good case of it too. He showed that the import value of the coal-tar chemicals used in the United States was less than the value of the confectionery sold over the 5- & 10-cent counters.

Our most eminent student of chemical statistics in a most comprehensive study pointed out the complexity of the industry and its difficulties, and concluded that we could have the industry if we were willing to pay the price. The question the manufacturer had to ask himself was: Who is to pay the price?

The would-be manufacturer also found that the duty-paid value of the coal-tar dyes and chemicals, assuming the adoption of the highest duties to be hoped for, would not be over \$15,000,000 per year on the basis of pre-war values. He further found according to authoritative statements that 922 different dyes were necessary, these being dependent upon about 300 intermediates made from ten coal-tar crudes by the use of vast quantities of acids, alkalies and other chemicals.

The business had a pot-walloping look at the best, and the American genius for production has not been of the pot-walloping order. However, the statement in regard to 922 dyes referred to above was based on the number of dyes listed in the 1914 edition of the *Schultz-Tabellen* and not on an analysis of the American dyestuff problem as it existed.

## FORMULATING THE REAL PROBLEM

The problem for solution by the American dyestuff manufacturer might have been stated somewhat as follows: To provide such a line of coal-tar dyes as in variety of hue, method of application, and fastness, will meet the needs of the textile and other manufacturers in these respects, having in mind the requirements of the ultimate consumer for service on the one hand, and the exigencies of manufacture on the other.

An analysis of the problem so stated made it seem possible to meet the legitimate demands of the situation with about 300 dyes derived from about 100 intermediates. Further analysis seemed to indicate that it might be possible to put the main part of the business on something better than a pot-walloping basis. If the industry is to be carried on by a large number of small concerns however, each endeavoring to bring out a complete line, it will be a business of small units and high labor costs.

In the following analysis the estimated needs of the whole country for the volume and kind of manufacture carried on before the war, has been taken as the basis.

The war conditions of today, however, have "busted the whole plan of salvation." But the war must be over some day, and the manufacturer who would survive must look forward to that day as well as take care of the emergency needs of the present.

## ANALYSIS OF UNITED STATES' DYE NEEDS

An annual American consumption of 50,000,000 lb. of coal-tar dyestuff has been assumed, and the information disclosed by the "Norton census" has been applied to the original estimates.

The necessary dyes were placed in five classes according to the quantities needed annually.

First Class.—Consumption in excess of 1,000,000 lb.



per year. Eight dyes fell in this class with a total of 25,000,000 lb. or one-half of the whole.

Second Class.—Consumption less than 1,000,000 lb. but 250,000 lb. or more. Twenty-seven dyes fell in this class with a total of 10,500,000 lb.

Third Class.—Consumption from 100,000 to 250,000 lb. Fifty-one dyes fell in this class with a total of 7,100,000 lb.

Fourth Class.—Consumption from 50,000 to 100,000 lb. Forty-seven dyes fell in this class with a total of 3,200,000 lb.

Fifth Class.—Consumption less than 50,000 lb. Approximately one hundred and sixty dyes would fall in this class with a total of 4,200,000 lb. or about 25,000 lb. each on an average.

So unless production of the same dyes was undertaken by too many independent concerns, a good part of the dyestuff manufacture could be put on a respectable production basis; that is, advantage could be taken of labor-saving devices and materials could be routed with some degree of order and system.

#### CHEMICAL PROBLEMS IN PRODUCING INTERMEDIATES

But there is another and more complex feature of the problem. To make these dyes the intermediates must first be made. We may estimate that our program will call for 100,000 lb. of an ortho isomer and find that in producing that amount of ortho we also get 200,000 lb. of the para isomer for which we have very little outlet. The ultimate success of the American dyestuff industry will depend largely upon the correct solution of just such problems. The solution of such problems will inevitably compel the manufacturer who would limit his business to a few individual dyes to increase his line, and increase will bring additional problems. But the manufacturer who piles up his para in order to sell ortho will certainly burn his fingers if he sticks to it.

Assuming that the 300-dye program is reasonably correct, the present status of the industry is encouraging. The estimate of the present status as here given is not based on the manufacture of any one concern but on the entire production of the country as far as it can be gaged by the products now on the market. The figures given below should not be taken as absolute. They are, however, approximately correct.

#### OUR PRESENT PRODUCTION OF DYES

Of the eight dyes placed in class 1, seven are being made now, in several cases in amounts considerably in excess of the original estimates.

Of the twenty-seven dyes in class 2, nineteen are now on the market and plants for the remaining eight are already in process of construction or projected.

Of the fifty-one dyes in class 3, twenty-six are now on the market and plants for nineteen of these remaining are being constructed or projected.

Of the forty-seven dyes in class 4, seventeen are now on the market and of the remaining thirty, plants are either under construction or projected for fifteen.

Of the large number of dyes in class 5, about sixty are on the market and sixteen are in prospect.

Not all the dyes mentioned as on the market are there in sufficient amounts, but if they can be made, it is only a question of increased plant to produce them

in sufficiency. The main problem as far as they are concerned has been solved, provided some inconvenient, not to be disposed of, isomer does not enter into consideration.

#### DEVELOPMENT IS PROCEEDING LOGICALLY

It is evident that the development of the American industry has proceeded on correct lines from the standpoint of the interest of all concerned. Those dyes required in largest amounts have actually been made first, and new projects have been undertaken roughly in the order of their importance as measured by the amount consumed.

This perfectly correct policy, however, has made it necessary to delay the production of some dyes, the importance of which is not measured entirely by the amount consumed. These dyes are those requiring comparatively small amounts of special intermediates. Obviously, such dyes require quite as much chemical and engineering investigation as those needed in larger quantities. It has certainly been the wisest course to apply the available chemical and engineering skill in such a way as to have it result in the production of the greatest possible amount of the commodities dependent upon dyes. The problems already solved also have their application in the solution of those as yet unsolved. There are few types of reaction employed in manufacturing dyes with which American chemists and engineers are not now familiar. The remaining problems, therefore, present fewer difficulties than the earlier ones. Then, too, many of the dyes needed in comparatively small amounts will appear simultaneously with dyes of greater importance, as the intermediate necessary for an important dye is frequently the one intermediate lacking for the production of a number of less importance.

With a few gaps here and there, the needs for acid, basic, chrome, and direct dyes are fairly well met with the dyes now available. With those in prospect, practically all needs will be satisfied for these classes.

#### QUALITY OF DOMESTIC PRODUCT EQUAL TO IMPORTED

Well-established American dyes made today by recognized manufacturers are equal in quality to the same dyes as formerly made in Germany. It is true that a considerable number of dyes formerly made in Germany are not as yet made in America. The lack of these dyes is partly responsible for the lack of fastness to light and wear being sometimes observable in textile fabrics. As a rule, however, such lack of fastness is due to faulty application, or to the wrong choice of available dyes for the job in hand.

Alizarin has appeared and its derivatives will follow. Vat dyes will not be long delayed. With good fortune, including a reasonable supply of chemists, labor, acids, toluol and phenol, the next year should see the American dyestuff industry a complete, accomplished fact.

Important as the establishment of this industry is for America, it is much more important that the war be won. Many of the essentials for making dyes are also essential for maintaining the military establishment, and the military establishment comes first. As between chrysophenine and TNT there is but one choice. So it may be safer to say that, subject to winning the

war, the next year will see the American dyestuff industry an accomplished fact.

The permanence of the industry is another matter. With Germany able after the war to lay goods on the dock in New York at pre-war prices, its permanence may be doubtful under existing tariffs. America has been shown that she can have a dyestuff industry at a price. What this price in the way of tariff protection may be no one can now estimate. But America knows the price she has paid for the lack of a dyestuff industry and will undoubtedly be willing to pay the price to keep the one she has gained.

American dyestuff manufacturers appear to be proceeding as though assured of a permanent industry.

Buffalo, N. Y.

## Ordnance Department Establishes Industrial Education Section

The Army Ordnance Department announces the establishment of an Industrial Education Section for the purpose of increasing productive efforts in the plants engaged in the manufacture of ordnance material.

The activities of the section are under the direction of Major F. L. Thompson and Captain C. R. Dickinson, and will be aimed to carry home to the individual worker, be he employer or employee, the fact that his own personal efforts will have a direct bearing on the winning of the war. The agencies employed include posters, booklets, pay-envelop stuffers, newspaper publicity, display advertising, motion pictures, public speakers and exhibits.

Posters carrying a message of encouragement to the worker tending to inspire greater individual effort are sent out to the manufacturing plants at regular intervals. Some of these, notably "Not Just Hats Off to the Flag, But Sleeves Up for It," have been remarkably successful, according to the more than 900 letters received by the Ordnance Department regarding it.

Booklets and pay-envelop stuffers are used to convey inspirational messages to the home and thereby tend to increase the morale of the community. An edition of 2,000,000 of one of the smallest posters ever issued, bearing a message to the individual, was distributed in a number of cities on Labor Day by means of aeroplanes dropping them over the course of the parade.

In the neighborhood of 1000 plants working on war materials now have motion-picture projection rooms and have been furnished films with a distinct appeal to the worker, such as the Government films, "Pershing's Crusaders" and "America's Answer." These films have proved very successful in definitely linking up the work of the man at the lathe with the boys at the front.

In the same manner, speakers, many of them foreign soldiers returned from the front, have been furnished to meetings of plant employees, and have given their hearers first hand information as to how necessary it is to speed up production.

Advertising and publicity in the newspapers by local communities has been advocated and copy furnished from Washington whenever desired.

In some instances, it has been found desirable to encourage public exhibitions of locally made material

used by the army as a means of arousing local pride and stimulating interest in war work. Several exhibitions of this kind illustrating the use to which the material was put in actual service, have been the direct means of increasing the pride of the citizens in their town and consequently in their own work.

In order to centralize the work and afford increased service to the various war working plants, it has been decided to appoint a representative of the Industrial Education Section in each of the eleven District Ordnance Offices as follows:

Bridgeport, Conn., Ralph B. Boas, formerly instructor at Brown and Harvard universities and a writer and lecturer of note; Boston, D. D. Cassidy, architect; New York, Major J. C. Mitchell, U.S.A., formerly president Etheride & Company, advertising agency; Philadelphia, J. W. Watson, president of the American Bronze Company; Rochester, N. Y., William H. Complice, Rochester Chamber of Commerce; Pittsburgh, Charles Yon, Pittsburgh & Lake Erie Railroad; Detroit, W. G. Pipp, editor *Detroit News*; Cincinnati, Carl H. Jacobs, Jr., vice-mayor and former assistant city solicitor; Chicago, D. L. Benjamin, of Gray & Benjamin, advertising agents; St. Louis, Homer Hall, assistant district attorney. The representative for the Cleveland district has not as yet been appointed.

These men are to be responsible in their respective sections for the activities of the Industrial Education Section which will act as a service agency at the disposal of the various District Ordnance Chiefs to assist them in increasing production effort.

## Chemically Treated Fabrics for Powder Bags

Chemically treated cotton cloth, as a substitute for silk, is being tested out by the Ordnance Department. If found practicable for ordnance uses, the discovery will effect the double result of meeting a serious shortage in silk, and of bringing about a money saving in the ordnance program estimated at between \$25,000,000 and \$35,000,000.

Preliminary tests already made at the Aberdeen Proving Grounds have encouraged the department to proceed further with its experiments; and for this purpose an order for 5,000 yards of the new material has been placed with the concern responsible for developing the process of treating the cotton cloth.

At present millions of yards of silk are required in making the bags which contain the large powder charges used in the firing of heavy artillery. These bags are inserted in the gun immediately behind the projectile, and the firing of them gives the propelling force that hurls the projectile at the target. This propelling charge is, of course, entirely distinct from the charge within the projectile that explodes the missile after it reaches the target.

Hitherto silk has been depended upon for these bags for the reason that no other cloth material has been found that would meet the peculiar conditions required. It is essential that not a particle of the bag container shall remain after the gun is fired. Otherwise a smouldering piece of the fabric might cause a premature explosion when a new charge was inserted.

# Large-Scale Sulphuric Acid Manufacture

A Description of the Plant of the Tennessee Copper Company Where the Special Features in Both Construction and Chamber Control Are as Noteworthy As the Fact that This Plant Is the Largest in the World

BY ANDREW M. FAIRLIE

Consulting Chemical Engineer, Copperhill, Tenn.

THE large plant for the manufacture of sulphuric acid may consist of either a large number of small or average units, all located at a single site and operated under one management, or a few units of unusually large proportions. In the former case the equipment and methods of operation need present nothing of extraordinary interest. The chambers, towers, fans, blow-cases, etc., may all be of a type and size with which the average acid-maker is familiar, and the operation of a number of small plants presents no difficulties or unusual situations which are not encountered in the operation of a single small plant.

An example of a large plant composed of a large number of units will be the new sulphuric acid plant now being erected for the U. S. Government at Brunswick, Ga. This plant will consist of eight units, each of 100 tons capacity. A 100-ton unit was formerly considered a large plant, but now that there are in this country so many units two or three times that size, the 100-ton unit has almost shrunk to average size by comparison. Another large plant, consisting of a large number of small units, is the plant of the United States Steel Corporation at Donora, Pa. This plant, comprising six units, each of 75 tons capacity, has a total capacity of 450 tons daily. Such plants as these, being a multiplicity of small or average units assembled or constructed at one site, contain presumably only the usual equipment, common to plants of average size anywhere.

## THE PLANT OF THE TENNESSEE COPPER COMPANY

It is the large plant composed of one or more extra large units that presents features of more than ordinary interest. The plant of the Tennessee Copper Company, located on the Ocoee River in the southeastern corner of Tennessee, is recognized as being not only the largest sulphuric acid plant in the world, but as being composed of the largest units in the world. The Tennessee Copper Company enjoys the distinction of being the original pioneer in the manufacture of sulphuric acid by the chamber process from the waste fumes of copper blast-furnaces. It is indeed fortunate that years ago the difficulties at first encountered were overcome, and that long before 1914 the enterprise had been put on a permanent and reliable basis, so that now, when acid is so much needed, and when sulphur and pyrites are so scarce, this large supply of sulphuric acid, made as a by-product, may be forthcoming to meet the needs of the Government.

The sulphuric acid plant of the Tennessee Copper Company comprises Plant No. 1 and Plant No. 2. Plant No. 1 is composed of two units, each of an average

daily capacity of 300 tons (60 degrees Baumé). These two units were formerly a single unit of 600 tons daily capacity, but in 1917 this large unit was subdivided into two approximately equal units. No. 2 Plant consists of one unit only, of a capacity of approximately 300 tons.

The five prominent features of a sulphuric acid plant are the burners, for generating the sulphur dioxide gas; the niter pots or retorts, for generating the oxides of nitrogen from nitrate of soda; the Glover tower, for denitrating the nitrous vitriol, concentrating the chamber acid, furnishing a part of the steam for the chambers, and cooling the hot burner gases; the lead chambers, the oxidizing, hydrating, and condensing apparatus; and the Gay-Lussac towers, for recovering the oxides of nitrogen in the form of nitrous vitriol. Less prominent, but quite as important features, are the gas fans, the acid pumps or blow-cases, the acid coolers, the hydration supply system, and the tanks.

The plant of the Tennessee Copper Company has no burners. The sulphur dioxide gas is generated in the copper blast-furnaces, and is conducted through a large brick flue to the Glover towers. This flue, the cross-sectional area of which is 200 square feet, is over 200 feet long to No. 1 Plant, and more than 500 feet long to No. 2 Plant. The percentage of sulphur dioxide in the gases ranges usually between 3 per cent and 6 per cent and the temperature of the gases entering the Glover tower may range between 600 and 900 deg. Fahr.

## EXTERNAL NITER RETORTS AND AUTOMATIC CHARGERS

The niter retort system now in use at these plants is unique. The common method of "potting" niter is to have the pots inside the hot-gas flue leading to the Glover tower, and to rely on the heat of the burner or furnace gases to distil the niter fumes from the pots. This method was formerly used at the No. 1 Plant of the Tennessee Copper Company. But it was found that some portion of the charge would overflow the pots, and from time to time a pot would develop a leak, permitting some of the charge to run out of the pot; and though due provision was made for tapping out such molten overflow or leakage from the pans underneath the pots, nevertheless, some of the overflow and leakage would inevitably solidify inside the hot-gas flue. Crusts of solid niter cake inside the flue would grow in size, until in course of time a solid mass would be formed in the flue, thus partially blocking the flue for the passage of gas and preventing the gas from getting free access to the pots in order to heat them, so that under these conditions it was neces-



sary to shut down the entire plant, once or twice a year, for ten days or more, in order to clean the niter cake out of these flues.

For this reason the pots inside the flue were abandoned, and a system of retorts outside the flue and fired with coal was installed. The retort adopted is the standard retort used in nitric acid manufacture, and is shown in Fig. 1.

This retort is ten feet high and eight feet in diameter, and is large enough to cook a charge of 8000 pounds of nitrate of soda without overflowing. The retorts are built in groups of three retorts to a chamber unit, but usually two retorts are sufficient to operate a unit, the third being held in reserve as a spare. Fig. 2 shows one of these groups of retorts.

Each retort is supplied with niter by an automatic feed device, motor-driven, and geared to a lead wheel provided with lead cups burned to its circumference, revolving in a small tank of acid in unison with the

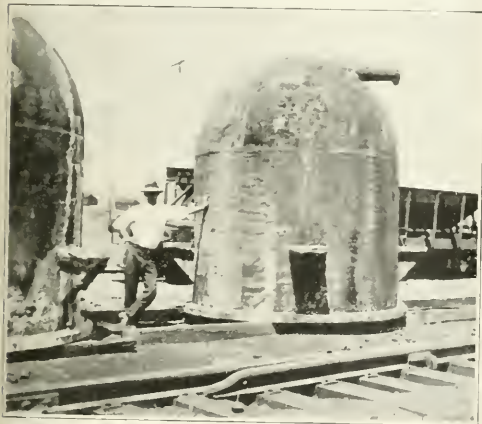


FIG. 1.—RETORT

revolutions of the worm which feeds the niter, so that automatically, as the niter is fed, the correct proportion of sulphuric acid is poured into the pot. Fig. 3 shows a close-up view of this mechanical feed for niter and acid.

The Glover towers of these plants are octagonal in shape, are 55 feet high and 30 feet in diameter from lead to lead. The lead curtains are lined with chemic 1 brick laid in acid-proof cement. The thickness of the brick walls at the bottom of the tower is  $22\frac{1}{2}$  in. The towers are packed with acid-proof tile. The amount of acid pumped over the three towers, combined, including nitrous vitriol and chamber acid, is about 3600 tons, or 72 tank car loads per day. The chamber acid is concentrated to a strength of about 60 deg. Bé. The temperature of the acid discharged from the Glover tower is about 280 to 300 deg. F., and of the gas escaping from the tower into the chambers, about 200. feet high, four chambers 22 x 50 x 77 feet high, four

#### SIX MILLION CUBIC FEET OF CHAMBERS

The lead chambers at No. 1 Plant are 34 in number, and are of unusual height. There are eleven chambers, 50 x 50 x 67 feet high, six chambers 50 x 50 x 72

chambers 18 x 50 x 77 feet high, four chambers 10 x 50 x 67 feet high, and five chambers 67 feet high, but of varying lengths and breadths. The total chamber space at No. 1 Plant is 3,944,800 cu.ft. At No. 2 Plant there are only four chambers altogether, but these are probably the largest acid chambers ever built. The dimensions are 59 ft. wide x 236 ft. long x 40 ft. high, each chamber enclosing 556,960 cu.ft. of space.

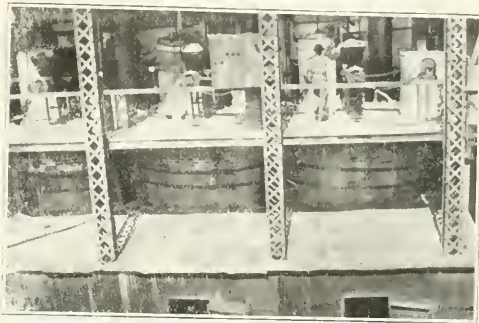


FIG. 2.—NITER RETORT GROUP

The total chamber space at No. 2 Plant is 2,227,840 cu.ft. For both plants combined the total chamber space is 6,172,640 cu.ft. At No. 1 Plant the chambers are connected by straight flues, these flues being alternately at the tops and bottoms of adjoining chambers. As most of the alleys between the chambers are only seven feet wide, most of the chamber connections are quite short. An exception to this rule is the flue con-



FIG. 3.—AUTOMATIC FEED

necting No. 6-B chamber with No. 7-B. These two chambers are so located that they are about 225 feet apart, and it was necessary to build a special flue to connect them. This flue, octagonal in shape and having a cross-sectional area of 100 sq.ft. and a diameter of 11 ft., has become quite famous throughout the country as the flue "big enough to drive an automobile through"—which is literally true of it. This flue has been referred to sometimes as the "Zeppelin Flue," from its resemblance to a Zeppelin airship. It is shown in part in Fig. 4, and its size looms large in comparison with the man standing beside it. The cross-sectional area of the other chamber connections at No. 1 Plant is approximately 100 sq.ft.

At No. 2 Plant the connections between the chambers are usually only seven feet long. But here each pair of adjoining chambers is connected by two connections (instead of by one only as at No. 1 Plant), each with a cross-sectional area of 25 sq.ft. There is one long, round flue, connecting the east side of No. 2 chamber with the west side of No. 3, by means of a return bend, whose diameter is 5 ft. 9 in.

#### SPECIAL SYSTEM OF GAS MIXTURE CONTROL

The chambers at both plants are provided with the usual equipment of thermometers and hydrometers for regulating the chamber temperatures and the strength of the "drips." While these instruments are used as aids in the control of the process, the quantity of niter admitted to the plant is regulated in accordance with the indications of the analytical method of chamber process control, originated by the author at this plant in 1910, and in continuous use there ever since.<sup>1</sup> This method of control has proved very useful at these

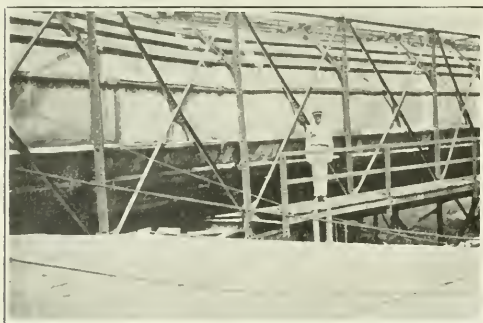


FIG. 4.—SULPHUR DIOXIDE FLUE

plants, on account of the fluctuating character of the furnace gases, and its use has resulted in a large saving of nitrate of soda. The method was described in detail in the *Transactions of the American Institute of Chemical Engineers*, Vol. IX (1916), pp. 319-332, and for a complete understanding of the method, the reader should refer to this publication.

Briefly, the method consists in the establishment, as the result of experiment, of a series of desirable ratios between the percentage of sulphur dioxide in the gas entering the Glover tower and the percentage of sulphur dioxide in the gas mixture at any fixed point in the front chamber, covering the entire range of sulphur dioxide percentages which are likely to be encountered; and in maintaining thereafter such desirable ratios constantly, by introducing the right amount of nitrate of soda for the purpose. Once the series of desirable ratios is established, they are arranged in tabular form, and the table is framed and posted before the eye of the chamberman. This man tests frequently the percentage of sulphur dioxide in the gas at the point in the front chamber chosen for the test, and by comparison with the percentage of sulphur dioxide in the gas entering the Glover tower at about the same time, knows by reference to the established table whether the amount of niter going into the system is too little,

too much, or just right. If any error in the amount is made, the error is detected in the front chamber, and the mistake is corrected before any serious damage is done. By this means it is possible to maintain uniformly the desirable percentage of sulphur dioxide in the gases escaping from the last chamber (from 0.06 to 0.12 per cent under normal conditions) thus securing the most efficient recovery of nitrous oxides in the Gay-Lussac tower.

#### TWO TYPES OF GAY-LUSSAC TOWERS

The Gay-Lussac towers at No. 1 Plant are eleven in number, and are of various shapes and sizes. Three of these towers, octagonal in shape, are 62 ft. 4 in. high and 35 ft. 7 in. in diameter from lead to lead; four smaller towers, also octagonal, are 70 ft. high and 19 ft. in diameter from lead to lead; and four square towers are 47 ft. high and 23 ft. square. These towers have lead curtains, lined with acid-proof brick walls laid dry; some are packed with quartz, and others with acid-proof brick or tile.

At No. 2 Plant the Gay-Lussac tower is of peculiar construction. There is only one tower, and it is built of acid-proof brick laid in acid-proof cement, without lead curtains. The tower is divided into 56 cells or compartments, the partitions being of acid-proof brick. The arrangement of the compartments is eight parallel rows of cells, seven cells to the row. The gases traverse the eight rows in parallel, and pass up one cell and down the next (and so on) of each row, until, arriving at the top of the seventh cell, they are drawn through the back fan and are then expelled through the exit stack into the atmosphere. The cells are each eight feet square inside, with a total height of 40 ft. They are packed with acid proof tile laid on edge. The distribution of the acid over the tops of the cells is effected by means of a single acid feed-pipe to each cell, terminating in a sprayer provided with a splash-plate inside the tower, by means of which the acid is quite evenly sprinkled over the entire top of the tower packing. The lead pan at the bottom of the tower is divided into three compartments by means of brick partitions, whereby it is possible to keep separate nitrous acid of three different grades of nitrosity, as discharged from the tower. The effect, then, of this peculiar tower, so far as the feed and discharge of the acid is concerned, is that of three towers arranged in series—the first (the one nearest to the chambers) consisting of eight rows of three cells to the row, over which the acid discharged from the middle group is fed, and from which the nitrous vitriol which is fed to the Glover top is obtained; the second, consisting of a continuation of the same eight rows, but with only two cells to the row, on which the acid discharge from the last group of cells is fed; and the third, consisting again of a continuation of the same eight rows of cells, two cells to the row, over which cooled acid discharged from the Glover tower is sprayed. This Gay-Lussac tower, or cluster of little towers, is of interest because of its peculiarity. After two years of operation, no particular advantage in this type of tower has been observed, but serious obstacles or disadvantages have been encountered, chief among which is the difficulty of washing the cells when they become clogged with acid sediment.

<sup>1</sup>See U. S. Patents, Nos. 1,205,723 and 1,205,724.



An unusual quantity of sediment is deposited from the acid made at these plants. This is because of the flue-dust blown out of the furnaces by the blast. At the ordinary plant, air is admitted to the burners or furnaces in a natural way, as induced by the draft of the acid plant. But in the case of the copper blast-furnaces air is blown into the tuyeres at the bottom

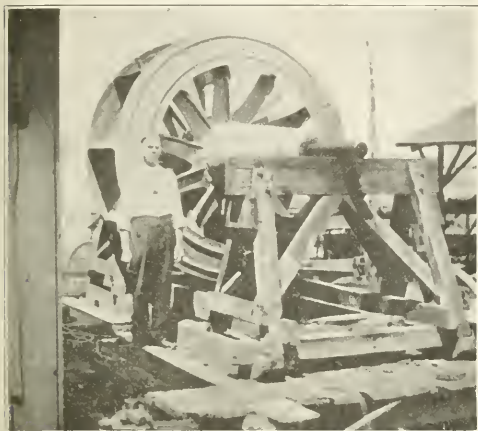


FIG. 5.—IMPELLER FOR  $\text{SO}_2$  GAS

of the furnaces under a pressure of about four pounds per square inch. This blast inevitably forces large quantities of fine particles of the furnace charge out of the furnace, and although brick chambers have been provided for settling the dust before the gas reaches the Glover tower, a substantial quantity of the finer dust enters the Glover tower with the gas, and encountering there the streams of acid flowing down the tower, is washed out, to form a stiff paste which collects at the bottom of the tanks. But not all of the solid impurities are eliminated from the gases, even in the Glover tower. Zinc fume, in particles so fine as to escape being washed out by the generous streams of acid pouring down the Glover tower, finds its way through the tower packing into the lead flues leading to the gas fans, and in the fans most of it is deposited as impure zinc sulphate, partly in the bottom of the fan casing, and partly on the vanes or blades of the impeller. A part of the zinc fume even goes on past the fan, to be deposited as zinc sulphate in the bottom of the chambers.

#### GASES PROPELLED WITH LEAD-ANTIMONY BLOWERS

As would be expected, the furnace blast produces a pressure on the hot-gas flues. This pressure is not sufficient, however, to force the gas through the chambers at the desired rate of speed; and moreover if reliance were placed exclusively on the furnace blast as motive power for the gases, the pressure on the hot-gas flues and on the furnace tops would be so great that not only would a large proportion of the gases be lost, but conditions on the furnace charge floor would be intolerable for the smelter workmen. Gas fans, therefore, have been installed for the purpose of drawing up the gases from the furnaces, and forcing them

on through the chambers. Gas fans are a common, and, indeed, a necessary adjunct, of any modern acid plant, but are usually much smaller in size than the fans about to be described.

The impellers of these fans, made of antimonial lead, are eight feet in diameter, and the vanes, of which there are ten to each impeller, are four feet wide. The vanes are attached to the hub by means of twenty cast arms or spokes. Keyed to the cast lead hub there is an inner hub of cast iron, and to this the steel shaft is keyed. The complete impeller, including shaft, cast-iron hub, lead hub, arms, vanes and shields, weighs approximately six tons. These impellers are made at the shops of the Tennessee Copper Company, and several have been made there for some of the large plants of the far West, which use this type of gas fan. Fig. 5 shows this impeller, and Fig. 6 shows the external appearance of one of these gas fans, the impeller being concealed by the housing.

#### BLOW-CASES SUPERIOR TO OTHER ELEVATING DEVICES

At No. 1 Plant seven of these fans are in operation, four at the front end of the chamber system and three at the back. At No. 2 Plant there are two front fans and two back fans.

Various means of pumping acid have been tried at these plants—blow-cases, electrically-driven centrifugal pumps (both horizontal and vertical types), electrically-

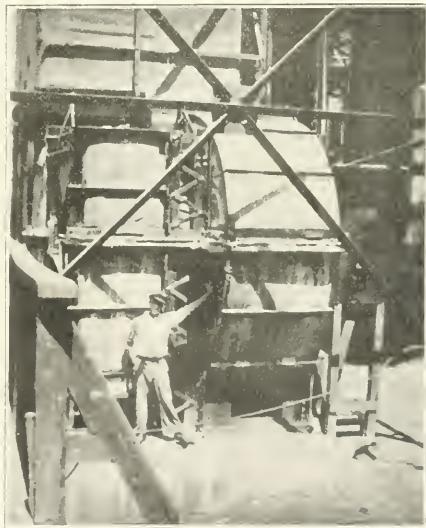


FIG. 6.—GAS FAN

operated skip-hoists, and air-lifts, and while some of the newer devices for elevating acid have shown lower costs than blow-cases as regards power consumption, from the standpoint of efficiency, operating labor required per unit of acid pumped, cost for repairs, total operating cost, and freedom from interruptions, no elevating device tried has equalled the compressed-air blow-case. For this reason all acid pumping done at these plants, with the exception of the elevating of the chamber acid (for which the air-lift is used) is now



done by means of blow-cases. The blow-case usually met with at an acid plant is made of cast iron; but at these plants blow-cases made of riveted wrought iron plates were adopted ten years ago, and have proved so successful that there has never been a cast-iron "egg" for pumping sulphuric acid on the place. The feed lines to these blow-cases are 6-inch iron pipes, and the discharge lines are 4-inch iron pipes.

Necessarily, for the purpose of cooling the enormous quantity of acid discharged from the Glover towers of these plants, coolers of special design had to be constructed. At No. 1 Plant there are six coolers, rectangular in shape, the inside dimensions being 17 ft. long x 8 ft. 6 in. wide x 4 ft. 8 in. deep. The frame-work is of steel channels placed edgewise to the cooler, supporting a shell of 15-lb. lead, which is lined with 9 inches of acid-proof brick laid in acid-proof cement. Each cooler contains 71 coils of 1½-in. lead pipe, the coils being 12 inches in diameter. In the six coolers combined there are over four miles of 1½-in. lead pipe. Three of these coolers are built in terrace form so that the acid flows by gravity from one cooler to the next, and this is found to be an advantageous arrangement. At No. 2 Plant there are three coolers of the same type and size as those at No. 1. By means of these coolers the Glover tower acid is cooled from about 280-300 deg. to 100-110 deg. F.

#### ATOMIZED WATER USED IN CHAMBERS IN PLACE OF STEAM

The hydration of the acid in the chambers of these plants was formerly accomplished by means of steam. Water sprayers had seemed out of the question on account of the limited capacity of the sprayers on the market. An enormous number of these low-capacity sprayers would have been required to supply the quantity of water needed for the large-scale operations here under way. A special atomizer has been developed at this plant, however, capable of atomizing as much as fifty gallons of water per hour, and with this device water-spray has been substituted for steam in most of the chambers, resulting in a considerable saving in coal, lower temperatures in the chambers, larger chamber capacity, and apparently some saving in niter consumption. As the water for the sprayer is pumped by means of centrifugal pumps operated by electrical motors driven by water-generated current, the saving of the coal formerly used to generate steam for the chambers is complete.

#### WROUGHT-IRON BLOW-CASES AND TANKS BEING INSTALLED

The factory tanks at No. 1 Plant have been, until lately, of the usual wooden construction, lead-lined. When No. 2 Plant was built, in 1916, on account of the acid-resisting properties exhibited by the wrought-iron blow-cases, it was decided to try wrought-iron factory tanks. Accordingly, all of the tanks serving as acid reservoirs at the tops and bottoms of the towers, with the exception of one wooden lead-lined tank at the top of the Glover tower for chamber acid, were made of wrought iron. Two years service has proved that the experiment was justified, as the repair account for these tanks has been practically nil, and caliper measurements of the thickness of the iron shows that the

tanks have still some years to live. At No. 1 Plant, as the wooden lead-lined tanks become unserviceable, they are being replaced by iron tanks.

The storage tanks for these plants have been placed at such an elevation (with the exception of one tank) that the acid flows to them from the plant by gravity. These tanks are made of steel or wrought iron. The total storage capacity, including two tanks of 5000 tons capacity each, is 23,000 tons.

From the storage tanks the acid flows by gravity into tank cars for shipment, and with the clamping of the lid on the dome of the car, and the pasting of the diamond-shaped label on the sides and ends, the work of making a carload of acid is finished.

But while the work, with reference to any particular tank-car of acid, may be considered completed with the shipping of the car, the work of the acid-maker goes on in a cycle as endless as the flow of Glover acid to the Gay-Lussac top, down the Gay-Lussac tower to its bottom, thence as nitrous vitriol up to the Glover top, and down that tower back to the bottom, appearing again as Glover acid.

### Resumption of Sulphur Production

Advices to the Chemicals Division of the War Industries Board are that mining operations have been resumed in part at the plant of the Union Sulphur Company, at Sulphur, La., where considerable damage was done by the hurricane that swept over that region on August 6. Shipments of sulphur were resumed last week from the accumulated stocks and rapid progress is being made in the work of restoring normal conditions. Considerable rebuilding will have to be done but ample material is on hand for the work.

The company carried immense reserves of sulphur above ground so that there will be no interruption in the manufacture of sulphuric acid and other necessary war materials. This reserve pile of the Union Sulphur Company measures 800 feet in length by 200 feet in width, 40 feet high, and represents about fifteen months' mining.

The plant of the Freeport Sulphur Company at Freeport, Texas, is producing its normal tonnage and has a considerable reserve above ground. While the damage to the Union Sulphur Company is unfortunate, especially at this time when sulphuric acid is being produced in such an enormous way, the reserve stock situation is such that there is no cause for worry. The Union Sulphur Company's operatives are working day and night in the rebuilding of their plant. The sulphur is melted in the ground by steam and hot water and forced to the surface where the molten sulphur solidifies on exposure to the air. The sulphur deposit underlies a bed of quicksand through which it is impossible to drive shafts and mine in the ordinary way. The development of this project is one of the interesting mechanical and chemical achievements of the past decade and, together with the Freeport Company's development, makes the United States by far the greatest producer of sulphur. There are two other known deposits which can be quickly opened in case of necessity. Work is now progressing on the development of one of these deposits.

## Dyes from the Manufacturers' Standpoint

**American Dye Makers Have Made Remarkable Progress in Furnishing Types of Dyes Formerly Imported—Lack of Variety of Intermediates Responsible for Failure Thus Far to Manufacture All the Dyes Desired**

By LOUIS JOSEPH MATOS, Ph.D.  
Chemist National Aniline & Chemical Company, Inc.

WHILE coal-tar dyes have been manufactured in the United States for many years, it has only been since the outbreak of the war that it can truly be said that dyes of strictly American origin have been produced. This point has been referred to many times by other writers, who drew attention to the fact that we do not have in this country the so-called industry of the intermediates from which American dye makers could draw their initial supplies. As a consequence, such dyes as were made in the United States were necessarily produced from intermediates that had been regularly imported from Germany.

When the war broke out, and the stocks on hand of imported and such domestic dyes as were finished were becoming rapidly depleted, the necessity arose compelling the production of intermediates from domestic raw materials and this production has gradually increased until the present time, when quite a respectable number of such commodities are now available. For some few years prior to the war aniline had been regularly manufactured at the plant of the Benzol Products Company, now the Benzol Works of the National Aniline & Chemical Co. Inc., but, it was not until after the war that secondary products, derivatives of aniline, were seriously contemplated.

Naturally in the manufacture of dyes to meet commercial conditions the manufacturers, of course, took up the production of those coloring matters that could be most readily prepared from easily manufactured intermediates, for it must be remembered that with a few given intermediates it is possible to produce quite an additional number of finished dyes. With crudes being rapidly absorbed by the explosive industry the manufacture of intermediates was put to serious disadvantage, and consequently the output of raw materials for the dye maker was extremely limited. Coupled with this was the great difficulty in securing men sufficiently trained in the chemistry and manufacturing operations. A great many men took up the manufacture of these products who did not possess a practical acquaintance with the intimate workings of the operations, but who by intensive application and pretenses succeeded in overcoming conditions which, under other circumstances, might have proved unsuccessful.

### AN IMPOSING LIST OF INTERMEDIATES AND DYES

The industry of the intermediates as it stands today in this country is remarkable for the variety of its products, which includes an imposing list of derivatives obtained from benzol and its homologues, numbering about 30, while the list of naphthalene derivatives, including a number of the complicated naphthol and

amido-disulphonic acids, is worthy of special mention. Referring to these naphthalene derivatives used as the starting point for the manufacture of a number of dye-stuffs, it should be kept in mind that with very few exceptions the production of each one constitutes a distinct industry made up of a number of operations. For their proper conduct is necessary a body of men of special training, whether chemists, engineers or workmen, and whose labors are not diverted to other manufacturing operations. Their manufacture is an example of highly specialized work. Some of the chemists who undertook this work were even unfamiliar with the methods of analyzing the finished product, some were unacquainted with the appearance of the operations as one succeeded the other, all of these had to be worked out—there were many failures interspersed with a few successes. But gradually as experience was gained better and more concordant results were being secured, so that in time the quality and the output of the items were constantly increasing.

As the number of the intermediates increased, the number of dyestuffs likewise increased, but the dyer and calico printer were constantly insisting upon a wider range and better dyes and these demands consequently stimulated the dye maker, with the result that during the last forty months the number of dyes actually upon the market increased until there are now about 175 separate and distinct coloring matters of coal-tar origin available and this list is being constantly added to. It is unnecessary to record in this article the list of those dyes, but it may serve our purpose to draw attention to the fact that there are many important members of the group of acid dyes; a wide range of dyes belonging to the direct dye color group; developed colors—a small but gradually increasing number belonging to the same group; sulphur colors—the great majority of which find their application to the production of khaki and olive-drab shades for military purposes; chrome colors which produce the so-called fast shades upon wool with the aid of chromium, a notable example of which is the fast chrome blue used almost exclusively for the dyeing of cloth for sailors' uniforms; and a number of basic dyes which have always occupied a prominent position in the art of textile coloring.

### INDIGO AND ALIZARINE NOW PRODUCED HERE

A number of other products should not be overlooked which do not belong to the above mentioned groups. For example, synthetic indigo; there is now in the process of erection at the Marcus Hook Works, a plant of most modern construction from which will be produced at an early date very large quantities of indigo,

the process for which has been actively prosecuted for a long time and has ultimately reached the point of success where the engineers could take hold and proceed with active operation. At the Brooklyn works of the National company there is now being regularly produced alizarine, from which the dyer produces on cotton the well known Turkey Red shade, and from which may also be obtained a number of other coloring matters, broadly included in the so-called group of alizarine dyes, and by this is meant *true alizarine*.

At one time the idea of producing alizarine in this country was regarded as the most remote possibility. This idea was based upon the fact that the essential raw material for the production was anthracene, which had never been isolated from our domestic tars and without which, of course, alizarine could not be made. When it was definitely decided that alizarine would be made in this country, the separation and refining of anthracene was taken up with energy, with the result that a quality of anthracene has been produced equalling in every way that which has been produced over in England or Germany, and the resulting alizarine, according to the testimony of all dyers, compares most favorably with that which was formerly imported. The energy displayed by the National company in the production of alizarine is merely an augury as to what may be expected by dyers and colorists along the lines of other dyes which are equally difficult to produce. Dyers, as well as consumers of colored textiles, have been insistent for some coloring matters that it has not been possible for the American dye makers to produce, at least for the present. The demand has constantly been made for fast dyes and the query has even been made, Is this or that dye equal to, or as fast as, dyes formerly imported from Germany?

#### OUR DYES EQUAL IN QUALITY TO IMPORTED

This brings forcibly to mind the fact which should not be overlooked, that no dye whether of German or of any other origin is absolutely fast. What the American dye maker tries to do is to produce dyes corresponding in type to dyes that were formerly imported. For example, let us select from the group of basic colors methylene blue. There is no question but that methylene blue possesses certain very good qualities and also certain qualities that do not condemn it for some uses, but the American dye maker has succeeded in duplicating identically methylene blue, and we are today producing in this country equal in shade, strength and working qualities the methylene blue that has been obtained from abroad prior to the war.

If we are asked, Are you making methylene blue as good as the Germans? we must emphatically answer in the affirmative. The same remarks apply to chrysoidine, the methyl violets, saffranine and Bismarck brown. If we refer to the group of sulphur colors with the same question asked us, Are you producing sulphur yellows or sulphur blues in this country equal to those formerly imported from Germany? we answer yes. But, if we are asked, Are you producing every one of such colors as those formerly imported? the answer necessarily must be No, for the reason that the industry of the intermediates has not yet kept pace with the demands. One of the most important groups of colors which interests the wool dyer particularly, is the so-called chrome colors above

referred to. From this class of colors alone the dyer is in position to select quite a number that possess the good qualities of extreme fastness, and many members of this same group now being manufactured in the United States are equal in fastness to their corresponding pre-war types. If again the question is asked, Are we manufacturing in this country every member of the chrome color group? we must again answer in the negative and offering again as the reason, that the industry of the intermediates has not yet supplied to the American dye maker every necessary raw material for the production of members of this important group.

#### CHROME COLORS FOR WAR NEEDS

Another reason also plays an important part, and that is military interests. With a war upon our hands and with conservation laying its hands upon wool in the interest of the army and navy, and we are likewise confronted with the fact that the fastest wool color is commandeered for military purposes and the output of the dye manufacturing plant capable of producing such color is almost solely taken over for war purposes. Coupled with this is the fact that to properly apply these chrome colors, chromium in the form of its well known chemical salts is needed, and the supply of chromium in the form of its ores is demonished so far as importations are concerned. Chromium in the form of chrome iron ore comes from widely separated localities, and while some has been mined in the United States the amount has been small in proportion to the consumption.

As used by the dyer, chromium takes the form of either bichromate of potash or corresponding soda salts. At the moment potash salts are out of the question, while soda salts are produced in limited quantities. The leather industry also requires large quantities of chromium for the chrome tanning process, producing leather for both shoes and harness, besides other military equipment. By far the small amount of chromium which comes to this country in the form of its ores finds its way directly to the steel works, where it plays its part in the war by aiding in the production of chrome steel, largely used for ordnance, projectiles, armor, etc. This disposition of the chrome ore imports is offered as a contributory reason why many chrome colors are now available to the general public

New York City.

**New Method of Preparing Monomethyl Aniline and Dimethylaniline by Catalysis.**—A. Mailhe and F. de Godon.—When a mixture of the vapor of aniline with a slight excess of methyl alcohol is passed over alumina heated at 400 to 430 deg. a mixture of mono and dimethylanilines is obtained which contains only traces of aniline. If methyl alcohol is again added and the process is repeated all the monomethyl derivative is converted into dimethyl aniline. After a certain time the alumina becomes yellow and then brown and its catalytic power is slightly diminished. On calcination it again turns white and recovers its activity. In this new method of preparing the monomethyl derivative the aniline need not be very pure, but may contain water, and the methyl alcohol need not be freed from acetone. The use of autoclaves, compressed air etc. is also avoided, and labor is reduced to a minimum.—*Comptes Rendus*, Vol. CLXVI, March, 1918.



# Direct and Indirect Methods of Nitrogen Fixation\*

Comparison of Operations Involved—Simplicity of the Direct Method—Layout of Battery of Coke Ovens, with Electric Power House and Nitrate Plant

By E. KILBURN SCOTT

I FEEL that the merits of the arc-flame process for making nitric acid have not been adequately and sympathetically considered, and this paper is written with the special object of stating them. I wish also to remove the misconception that the arc-flame process is dependent on water power and that it can only be installed economically on a very large scale. The matter is one of special interest to electrical engineers because the process is essentially an electrical one.

One method of producing nitric acid from air which I call the "indirect" method is first to make carbide of calcium, then treat it with nitrogen to form calcium cyanamide, from which ammonia and in turn nitric acid are obtained.

Another method is the "direct," which consists in combining nitrogen and oxygen of the air directly in the electric arc to form nitric acid.

Those interested in the indirect method have drawn comparisons between it and the direct electric arc process, with the object of showing that the indirect is the better. A tabular comparison of the operations involved in the two processes should thus prove of interest, since it is the only way in which a fair comparison can be made.

It is frequently stated that the amount of electric energy required for a given quantity of nitric acid produced by the indirect process is less than that required by the direct, and this is put forward as a strong argument in favor of the indirect method. The only way to compare two operations is to take into account all the factors which go to make up the total cost, and appraise each one at its proper value.

INDIRECT METHOD, EMPLOYING CALCIUM CYANAMIDE TO MAKE AMMONIA AND OXIDIZING THE AMMONIA TO ACID BY A CATALYST

DIRECT METHOD, EMPLOYING THE ARC FLAME FURNACE ONLY

## FACTORIES

- |                             |                         |
|-----------------------------|-------------------------|
| 1. To make calcium carbide. | 1. To make nitric acid. |
| 2. To make cyanamide.       |                         |
| 3. To make nitric acid.     |                         |

## OPERATIONS

- |                                                   |                                                                     |
|---------------------------------------------------|---------------------------------------------------------------------|
| 1. Burning limestone.                             | 1. Blowing air through electric arc flame to produce nitrous gases. |
| 2. Grinding lime.                                 | 2. Absorption of gases in towers to produce acid.                   |
| 3. Grinding coke or anthracite.                   |                                                                     |
| 4. Mixing lime and carbon in correct proportions. |                                                                     |
| 5. Making calcium carbide in electric furnaces.   |                                                                     |

6. Grinding carbide to fine powder in neutral atmospheres.
7. Making liquid air to produce nitrogen.
8. Packing calcium carbide into retorts.
9. Making calcium cyanamide by adding nitrogen and by use of electric resistors.
10. Emptying cyanamide from retorts.
11. Grinding cyanamide to a fine powder.
12. Hydrating cyanamide to rid it of carbide.
13. Making superheated steam.
14. Treatment of cyanamide with steam in autoclaves to produce ammonia.
15. Oxidation of ammonia to produce weak nitrous gases by means of a catalyst.
16. Absorption of gases in towers to produce acid.

## RAW MATERIALS

- |                                           |                      |
|-------------------------------------------|----------------------|
| 1. Lime.                                  | 1. Air.              |
| 2. Coke.                                  | 2. Metal electrodes. |
| 3. Carbon electrodes in carbide furnaces. | 3. Water.            |
| 4. Carbon resistors in cyanamide retorts. |                      |
| 5. Pure nitrogen.                         |                      |
| 6. Superheated steam.                     |                      |
| 7. Air.                                   |                      |
| 8. Water.                                 |                      |

## ELECTRIC ENERGY FOR

- |                                                     |                        |
|-----------------------------------------------------|------------------------|
| 1. Carbide furnaces.                                | 1. Arc-flame furnaces. |
| 2. Grinding carbide.                                |                        |
| 3. Cyanamide retorts.                               |                        |
| 4. Grinding cyanamide.                              |                        |
| 5. Heating catalyst.                                |                        |
| 6. Motors for power etc., including several cranes. |                        |

## SKILLED LABOR FOR

- |                          |                       |
|--------------------------|-----------------------|
| 1. Carbide furnaces.     | 1. Arc-flame furnace. |
| 2. Cyanamide retorts.    | 2. Absorption plant.  |
| 3. Packing cyanamide.    |                       |
| 4. Grinding machinery.   |                       |
| 5. Making pure nitrogen. |                       |
| 6. Making ammonia.       |                       |
| 7. Catalytic process.    |                       |
| 8. Absorption plant.     |                       |

## COMPARISON OF COST OF PLANTS AND OPERATIONS

Obviously, the cost of a plant using the indirect method, will be very much greater than that using the direct, for if we assume that the cost of a carbide furnace and its accessories is about the same as that of an air nitrate furnace with its accessories, then the indirect process embraces in addition:

\*Abstract of a paper presented at the 34th Annual Convention of the A. I. E. E., Atlantic City, N. J., June 27, 1918.

1. A complete plant for making cyanamide.
2. A liquid-air plant for making pure nitrogen.
3. Powerful machinery for grinding the carbide and the cyanamide.
4. Steam boilers and autoclaves for making ammonia.
5. A complete catalytic plant for oxidizing the ammonia to nitric acid.

In the indirect method it is essential to have all the materials, gases etc. absolutely pure: for example at the cyanamide works at Odda in Norway it was necessary to carry a pipe up the mountain side so as to insure a supply of pure air to the liquid-air plant.

When carbide is converted into cyanamide some of the former remains unchanged and in order to obviate danger of explosion a special treatment of the mixture is necessary to insure a total decomposition of the remaining carbide.

Platinum is usually employed and in order to "reactivate" it, it is necessary to subject it to an acid treatment and eventually to remelt, in which process it is impossible to avoid loss of this expensive metal.

By the direct method the cost of air is nil, and the cost of water is practically that of pumping. On the other hand, the materials required in the indirect method are very expensive and especially difficult to obtain at the present time. Over three-fourths of the cost of working the indirect process is represented in materials liable to price fluctuation. These are now much higher than before the war, and will remain at the higher level after the war.

In the direct method less than one-fifth of the total cost is represented in materials dependent on market rates, and the principal item of cost, namely, electric power, will, if anything, tend to come down in price.

The direct method is very simple to operate, while the indirect requires much skilled and unskilled labor, and some of the operations are dangerous to health. Therefore, the more labor demands increase, the more the indirect method will be handicapped in this respect. There are many separate links involving exact operating to make the whole run smoothly; the slightest hitch in connection with any one link necessarily holds up the whole system.

The manufacture of cyanamide has to be carried out in retorts of relatively small size involving much labor to set up etc. This is to enable the nitrogen gas to penetrate to all parts of the contained carbide. The times of the reaction and the cooling down etc. are definitely fixed and it is quite impossible to work the process with off-peak power; moreover, should there be an accident or failure of current for a time, there is every chance of ruining both the cyanamide retorts and the carbide furnaces.

All nitrate processes have a military bearing as regards preparedness, in which is involved the question of transportation. The heavy and bulky raw materials necessary for the indirect process place it at a serious disadvantage from this point of view, especially at the present time when the railways are so congested; with the direct process there is no carriage of raw materials.

As a basic load for a power house the direct arc process presents the advantage that it can be established anywhere, because, the raw materials being only

air and water, considerations of transportation do not enter into the situation.

It is particularly suitable for off-peak or off-season loads, for there is no fused material to solidify and little to deteriorate in case of stoppage. Some of the furnaces can be switched on and off like an arc lamp without detriment to brickwork or structural details, or to the process of manufacture.

As there seems to be some doubt as to the possibility of running arc furnaces intermittently on a commercial scale, I would mention that about seven years ago a nitric acid factory was built at Legnano, Italy, to utilize 10,000 horsepower, especially during the night (see "Utilization of Atmospheric Nitrogen" by T. H. Norton, p. 68). Of course this plant has been considerably extended, especially since the war. I am also credibly informed that in Germany there is a very large arc-process plant working with off-peak power. At any rate there is no difficulty in doing it, whereas it is impossible to work intermittently with any other method of fixing atmospheric nitrogen.

In some ways, it is an advantage to run a plant for 8000 hours per year or less instead of the full number, because the spare time can be conveniently used for renewals and repairs. Less spare time is thus required and the plant can be operated by two shifts of men.

#### SMALL PLANTS PROFITABLE

Because the plants in Norway are very large and use only hydro-electric power, a myth has spread that the arc-flame process can be worked commercially only on a very large scale, and then only with water power. As a matter of fact, it is well worth while to build plants of 10,000-kw. consumption.

Indeed, hydro-electric power may be a disadvantage because of its distance from industrial centers, for either the factory has to be placed in an out-of-the-way location, or else the power has to be carried over a long transmission line. I am of the opinion that electro-chemical factories should be placed near the power supply, and the ideal position is alongside the power house, especially if off-peak power is used.

In a national emergency it is surely better to bring into immediate use all the surplus equipment that already exists than to start building new power houses, whether hydraulic or steam, and inasmuch as the direct-arc-flame process is suitable for working with off-peak power, I would suggest that a number of nitrate plants be forthwith erected at existing power houses.

By erecting ten or more nitrate plants of 10,000 kw. each at power houses near places where nitrates are required, there would be considerable saving in transportation; early deliveries of nitrate could be made. Furthermore, there would be less risk of temporary interruption of supplies in case of accident or sabotage.

There are power houses which could easily spare more than 10,000 kw. for over 20 hours a day and over the week end. Moreover, there are power houses fully equipped with steam plants which are now standing idle. In the present crisis they might just as well be brought into use even if the cost of generation is high.

In some power houses the load factor might be doubled; this would have the immediate effect of reducing costs. But there has been far too much shilly-

shallowly consideration given to questions of cost. With U-boats on the high seas trying to stop supplies of Chile nitrate, the railways congested with traffic and electrical engineering works making munitions, what is the use of discussing power costs?

### COKE-OVEN AND NITRATE PLANTS

At the present time ammonium nitrate is required in very large quantities for burster charges for shells, torpedoes, mines, grenades etc. This is made from two components, viz., nitric acid and ammonia, both of which are difficult to transport, the first because it is a corrosive acid and the second because to every ton of aqua ammonia there are about 2½ tons of water. An industrial process capable of furnishing electric energy as well as a supply of ammonia would be ideal, and it so happens that this is the case with a regenerative coke-oven plant. Half the total gas made is available and this can be easily turned into electric energy while at the same time the nitrogen contained in the coal provides about the right amount of ammonia necessary to combine with the nitric acid made from the electric energy by the arc-flame process.

In order to show how ideal such a system is for making ammonium nitrate, I have prepared the diagram, Fig. 1.

The scheme provides for a combination of a battery of coke ovens with an ammonia-recovery plant together with an electric power house in order to utilize

as shown in the diagram for the purpose of making caustic alkali from brine.

It will thus be seen that the complete project requires only two raw materials, viz., coal and brine, and on the other hand, the products which can be made are coke and ammonium nitrate, together with toluol, benzol, naphtha, tar and sodium nitrate-nitrite.

If electrolytic cells are used, there are also the products chlorine and bleaching powder. The chlorine can be combined with the benzol to form chlor-benzol which is an important intermediate in the manufacture of dyestuffs as well as in the manufacture of picric acid.

From the point of view of efficient management and elimination of transportation charges, the combination is unique, for the ammonia has to be piped only a few yards to the nitrate house and there is no carriage of acid.

As a cheap supply of coal is indispensable for the project, it would be well to locate the plants at industrial centers where this raw material is readily available and where in all probability transportation charges would be low.

### YIELD OF A 100-OVEN BY-PRODUCT PLANT

In order to show what can be done with a coke-oven plant the following particulars will be of interest. I take a Koppers type of oven as being the best known.

| Quality of Coal                                                             | Tons per charge | Hours coking time |
|-----------------------------------------------------------------------------|-----------------|-------------------|
| Low-volatile coal                                                           | 13½             | 18                |
| Mixture containing 80 per cent high-volatile, 20 per cent low-volatile coal | 12½             | 16½               |
| High-volatile coal                                                          | 11½             | 15                |

A battery of ovens varies in size but we may as well take a round number of 100, for which the average yields are as follows:

|                                          |        |
|------------------------------------------|--------|
| Number of ovens                          | 100    |
| Tons of coal per oven                    | 12½    |
| Hours coking time                        | 16     |
| Total yield of coke, per cent.           | 72     |
| Yield small coal and breeze, per cent.   | 5      |
| Net yield good coke, per cent.           | 67     |
| Ammonium sulphate per ton of coal, lb.   | 25     |
| Reckoned as ammonia per ton of coal, lb. | 6½     |
| Tar per ton of coal, gal.                | 9      |
| Light oil per ton of coal, gal.          | 3      |
| Total gas per ton of coal, cu.ft.        | 11,000 |
| British thermal units, per cu.ft.        | 550    |
| Surplus gas, per cent.                   | 55     |
| Surplus gas per ton of coal, cu.ft.      | 6,000  |

Such a battery of ovens, each of which distills 12½ tons of coal in 16 hours, will deal with

$$100 \times 12.5 \times 24 = 1900 \text{ tons per day.}$$

Assuming 6000 cu.ft. of surplus gas per ton of coal and 550 B.t.u. per cu.ft., the total heat value per hour will be

$$\frac{1900 \times 6000 \times 550}{24} = 260,000,000 \text{ B.t.u.}$$

If employed in gas engines using 13,000 B.t.u. per hp.-hr., the power will be

$$\frac{260,000,000}{13,000} = 20,000 \text{ hp., or about 14,000 kw.}$$

If steam boilers and turbines are used instead of gas engines, the power will be less; so to be on the

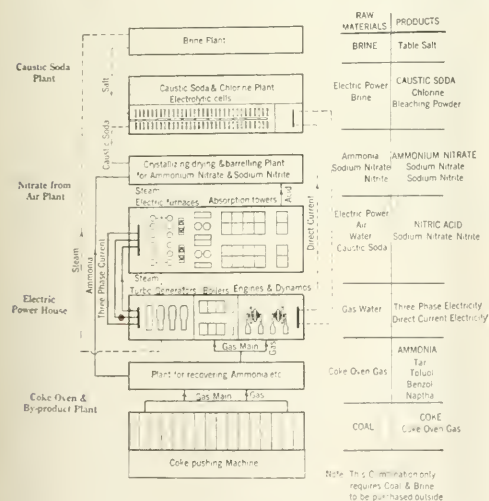


FIG. 1. SYSTEM FOR MAKING AMMONIUM NITRATE

the surplus gas. Alongside of the power house, there is an electrochemical plant for the manufacture of nitric acid from air by utilizing the three-phase high-tension current. A nitrate house is provided for the purpose of combining the ammonia from the coke ovens with the nitric acid from the electrochemical plant.

It happens that the by-product of the acid factory is sodium nitrate-nitrite, which is made by combining the gases remaining from the acid towers with caustic soda or soda ash. Electrolytic cells may be laid down



safe side, we will take the round figure of 10,000 kw.

We will also assume that electric furnaces utilizing 10,000 kw. for a whole year can produce 6300 tons of 100 per cent nitric acid capable of furnishing theoretically 8000 tons of ammonium nitrate, as indicated:

|                        |                                                       |      |      |
|------------------------|-------------------------------------------------------|------|------|
|                        | $\text{NH}_3 + \text{HNO}_3 = \text{NH}_4\text{NO}_3$ |      |      |
| Molecular weights..... | 17                                                    | 63   | 80   |
| In short tons.....     | 1700                                                  | 6300 | 8000 |

Allowing 25 lb. of sulphate of ammonia or  $6\frac{1}{2}$  lb. of ammonia per ton of coal, a total consumption of 1900 tons of coal per day should give

$$1900 \times 365 \div 6.5 = 2250 \text{ tons per annum.}$$

It will thus be seen that there is plenty of ammonia to combine with the acid made by the surplus gas, even if a higher yield of acid is allowed per kw.-yr. and more power is generated.

I purposely leave out of consideration questions as to types of nitrogen fixation furnaces and of yields obtained. I may say, however, that it is not right to assume that yields are limited to those usually obtained from certain well-known furnaces which must of necessity work with single-phase current.

The amount of ammonium nitrate will be less than the theoretical figure because the efficiency of the reaction is not 100 per cent; moreover, it is usual to convert a certain amount of the gas into sodium nitrate-nitrite. A safe figure would be 6000 tons and at this rate it can be shown that with electric energy at 5 mils per kw.-hr. and ammonia at 13c. a pound, the ammonium nitrate can be made at less than half the price the government is now paying.

#### MAGNITUDE OF THE NITROGEN INDUSTRY

In order to show how large a business the nitrogen industry has become, the following figures (compiled by Dr. Paul J. Fox) give the nitrogen balance sheet for the United States for 1917.

##### IMPORTED SUPPLIES

|                                                                              | Tons of 2,000 lb. | Tons of Nitrogen |
|------------------------------------------------------------------------------|-------------------|------------------|
| Chile saltpetre, 95 per cent $\text{NaNO}_3$ .....                           | 1,742,540         | 272,880          |
| Ordinary saltpetre, potassium nitrate.....                                   | 4,609             | 645              |
| Ordinary saltpetre and gunpowder containing 75 per cent $\text{KNO}_3$ ..... | 1,500             | 210              |
| Ammonium sulphate.....                                                       | 8,135             | 1,720            |
| Ammonium chloride.....                                                       | 1,073             |                  |

##### DOMESTIC SUPPLIES

|                                                |         |        |
|------------------------------------------------|---------|--------|
| Coke oven ammonia— $\text{NH}_3$ .....         | 113,760 | 93,625 |
| Gas works ammonia— $\text{NH}_3$ .....         | 12,500  | 10,288 |
| Calcium cyanamide at 20 per cent nitrogen..... | 12,800  | 10,534 |

##### NITROGEN EXPORTED

|                                                           |         |        |
|-----------------------------------------------------------|---------|--------|
| Nitric acid, 15 per cent nitrogen.....                    | 486     | 73     |
| Picric acid, 18 per cent nitrogen.....                    | 26,610  | 4,790  |
| Dynamite, 12 per cent nitrogen.....                       | 8,962   | 1,255  |
| Gunpowder and smokeless powder, 13 per cent nitrogen..... | 223,270 | 29,025 |
| Ordinary saltpetre.....                                   | 875     | 123    |

In addition to the above, there is also about 8800 tons represented as nitrogen in the following items which are the figures for 1917.

|                             | Value         |
|-----------------------------|---------------|
| Loaded cartridges.....      | \$42,000,000  |
| Fuses.....                  | 34,000,000    |
| Shells and projectiles..... | 74,000,000    |
| All other.....              | 202,000,000   |
| Total.....                  | \$253,000,000 |

It will be noticed that ammonium nitrate is not included in these figures, but I assume it would be about 50,000 tons for 1917.

In Great Britain the consumption of ammonium nitrate is now probably 400,000 tons a year, and the

production here will have to be at least as much. To make this, the theoretical proportion of ammonia required is about 85,000 tons and of nitric acid about 315,000 tons.

It will thus be seen that the coke-oven plants in the country could supply all the ammonium nitrate required if they were put on the job.

#### GENERAL CONSIDERATIONS

Until recently most coke-oven ammonia was converted into sulphate, but owing to the war demand for nitrate, more and more of it is being made into aqua ammonia of about 29 per cent strength. In some cases this is being transported many hundreds of miles prior to conversion into ammonium nitrate and since each ton of ammonia necessitates the transportation of about  $2\frac{1}{2}$  tons of water, the bearing of this on the present railway congestion is at once apparent. Tank cars have to be used and they must return empty, so the freight on the actual ammonia carried is extremely high.

There are many coke ovens of the wasteful bee-hive type in operation, which do not recover by-products. The replacement of these by modern coke-ovens would be a great immediate economic gain and meet the war conditions better than the building of large dams for water power.

In the present emergency coke ovens are of great value because they give coke for making steel, gas for power purposes, ammonia for nitrate manufacture, and toluol and benzol for explosives.

After the war ammonium nitrate will be in demand for fertilizer as well as for safety explosives and other purposes. The high percentage of nitrogen which it contains, 35 per cent, and the ease with which it can be converted into other compounds makes it especially useful for conveying nitrogen in the fixed form over considerable distances.

It is more profitable to make nitrate than sulphate, because pound for pound, the nitrate contains nearly twice as much fixed nitrogen and the nitrogen commands a higher price per unit when in the form of ammonium nitrate.

New York City.

#### Jellies Formed by Dyes

When certain substantive dyes, Benzopurpurin B and Chrysophenin B, are dissolved in hot water, solutions are obtained which jelly on cooling. The formation of the jellies seems to be dependent on small quantities of electrolyte in the dyes, for when the solutions are purified by dialysis, coagulation takes place and the coagulum is no longer soluble even in hot water. The addition of sodium chloride is, however, sufficient to bring the dye into solution. The experiments show that the small quantities of electrolytes (sulphates and chlorides) present in the commercial substantive dyes are very important in technical application, but as yet no satisfactory explanation of the phenomenon can be given.—*Kolloid Zeits.*

The volume of natural gas from which the output of natural-gas gasoline in 1917 was recovered is estimated to have amounted to about 429,000,000,000 cu.ft., and the average recovery of gasoline per thousand cubic feet was about one-half gallon.

# The Distillation of Coal in a Vacuum\*

## Nature of Products Obtained and Their Relation to Ordinary Tar and Petroleum in Chemical Constitution

By AMÉ PICTET

Professor of Chemistry, University of Geneva

WHEN we consider the part that coal plays in belief that this precious material had long been the modern world, we would be inclined to the subject of thorough and definitely scientific study, and that its chemical nature particularly was no longer a secret. As a matter of fact, this is not true. The chemistry of coal still presents considerable blanks. If we know accurately its elementary composition and the calorific power of all the varieties, if we know exactly all the products which it yields upon heating, we are still ignorant of what it is in its natural state and of what organic bodies it is composed.

This knowledge would be very important to science and industry, for it would render possible the solution of a number of important questions which are still unsolved and which have a bearing upon, among others, the genesis of fossil coals and their relation to petroleum and bitumens, upon the slow transformations to which they are subjected in the earth and to those more rapid transformations which they undergo during cokefaction, etc.

The ignorance in which we are left in this domain, however, must not be imputed to the indifference of the chemists; it is attributable only to the insufficiency of the means at their disposal. To separate the constituents of an intimate mixture, they have in effect but two processes: Fractional distillation and the action of solvents. Now, neither the one nor the other is practicable in this particular case, for coal is not volatile without decomposition and does not dissolve easily in any known liquid.

In spite of these inherent difficulties of the subject, I have thought that the latter deserved to be undertaken and that it would be possible to overcome some one of the obstacles by changing suitably the operating methods used up to the present time. Several years ago with the assistance of several co-workers, MM. L. Ramseyer, M. Bouvier, O. Kaiser and A. Labouchère, I entered upon some original research upon the chemical nature of coal. These studies are far from being finished; their first results have led however to some conclusions which may perhaps be interesting.<sup>1</sup>

### METHOD OF RESEARCH

We have been guided in our first experiences by the following considerations. When coal is distilled at atmospheric pressure as is practiced in gas works and in coke-plants, it is necessary, in order to extract all the volatile properties, to heat it to a very high temperature (800 or 1000 deg.). It is evident, that under these

conditions, the products that are collected, and which form the illuminating gas, the ammoniacal water and the tar, must be considered as pre-existent in the coal, and not as resulting from its immediate decomposition. They have undergone, due to the high temperature to which they have been brought, various transformations, the nature of which has escaped us. We cannot deduce from their chemical constitution any index as to the more complex compounds from which they have been derived.

There is only one way to avoid these transformations and that is to conduct the distillation at a much lower temperature and at a very reduced pressure. Acting upon this principle, we have subjected to vacuum distillation several kilos of a fat coal coming from Mont-rambert (Loire). The simple apparatus which we used has been described elsewhere, and I shall not repeat it. We have found that at a pressure of 15 mm. of mercury, distillation begins at about 100 deg. and that it is entirely terminated at 450 deg., that is to say, a little above the point where it would begin if operated under ordinary pressure.

### NATURE OF PRODUCTS OBTAINED

The products obtained are of an entirely different nature and are as follows:

1. *Gases.* The apparatus which we adopted did not permit us either to measure them or determine their composition; we have only been able to observe that their odor is much different from that of illuminating gas and resembles that of butadienes and isoprenes.

2. *Water.* About 1.6 per cent of the weight of the coal presented an acid reaction and did not contain ammonia.

3. *Tar.* About 4 per cent; very different from ordinary tar in appearance and all its properties.

4. The *coke*, lighter, more friable and more easily combustible than ordinary coke, resembled rather that which remains after the distillation of petroleum.

Of these products, the tar seemed to be the most interesting, and we studied it first. To procure a sufficient quantity, we applied to the Society of Chemical Industry at Bâle which was so kind as to distill in a vacuum for our purpose one and one-half tons of the same Montrambert coal, which yielded us about 60 kilos of tar.

### THE VACUUM TAR

The vacuum tar, as we have called it, is a translucent liquid, light brown and has a light green fluorescence; it is more fluid than ordinary tar and has an odor very different, resembling that of petrol. Immediately after its preparation it floats upon the water which it has entrained but it soon thickens, sinks and increases in

\*Translation from *Revue Generale des Sciences*, Oct., 1916, Vol. 27, pp. 578-584.

<sup>1</sup>For experimental details, see *Comptes Rendus*, vol. CLVII, pp. 779 and 1436; vol. CLX, p. 629, as well as the theses of M. Ramseyer (Geneva, 1911) and M. Bouvier (Geneva, 1915).

density. At the end of three days, the density is exactly equal to 1; it rises again eventually. This phenomenon takes place when the air is excluded as well as in the presence of air; it is not, therefore, due to oxidation.

In connection with this fact, it was observed that the tar agitated soon after its preparation with an excess of solution of caustic soda does not give up anything. Therefore it does not contain phenols, but the latter appear after a certain time and their quantity increases quite rapidly.

Treated with dilute hydrochloric acid, the vacuum tar yields a small quantity (about 0.5 per cent) of compounds of a basic nature. Their study has been undertaken by M. Labouchère. Some of these substances are secondary bases, and others tertiary. These belong chiefly to the hydropyridic and hydroquinoline series. The only two of which have been isolated thus far in their pure state have the formulae,  $C_{10}H_{11}N$  and  $C_{12}H_{13}N$  and very probably constitute dihydromethylquinoline and dihydro-trimethylquinoline.

After this double treatment by soda and by hydrochloric acid, the vacuum tar still contains some oxygen compounds (about 2 per cent). These can be obtained by boiling the liquid with sodium. The compounds have some of the properties of the alcohols. MM. Bouvier and Kaiser have been able to isolate by fractional distillation four well-defined representatives of this class of bodies. They answer to the formulas,  $C_7H_{11}O$ ,  $C_8H_{14}O$ ,  $C_9H_{17}O$  and  $C_{10}H_{20}O$ .

The first of these alcohols is saturated and constitutes the p-methyl-cyclohexanol (hexahydro-paracresol). The other three which form a homologous series belong to a group of unsaturated alcohols. Their structure has not yet been established; we have only ascertained that they are but slightly stable. Completely insoluble at first in alkalis, they become part soluble after a short time; the solution is disturbed when a current of carbonic gas is passed through it, and one can distinguish bodies having the odor and all the properties of phenols. This transformation which is probably isomerisation, furnishes the key to the phenomenon which has been a baffling question.

Once rid of bases and alcohols, the vacuum tar is nothing more than a mixture of hydrocarbons, of which some are saturated and others are not. To separate them we have made use of the Edelineau process, which has been employed for several years in the refining of petroleum. It consists in agitating the mixture, suitably refrigerated, with twice its volume of liquid sulphurous anhydride. Only the unsaturated hydrocarbons pass into solution and can be recovered simply by volatilization from the solvent. The saturated hydrocarbons serve to float the sulphurous solution and are separated mechanically. This process, applied to vacuum tar, has given us excellent results and has permitted us to separate our product very nicely into two parts, the one, unsaturated, the other saturated, the first having a volume about double that of the second.

We afterward subjected these two parts to a series of fractional distillations two degrees apart. The two parts behaved almost the same. The distillation began at 120 deg. and ended at 350 deg. There remains a small quantity of a black material of the consistency of asphalt.

All these fractions up to 300 deg. remain liquid after cooling. None of them deposits crystals. This indicates that no noticeable quantities of naphthalene, anthracene or other aromatic solid hydrocarbons are found. We have oxidized many of them by means of potassium permanganate and have found but few acids of the fatty series (acetic, propionic, butyric, oxalic). It seems very certain that vacuum tar contains no phenols nor any more hydrocarbons of the aromatic series.

We have studied the lower fractions especially. They are liquids, insoluble in water and volatile with it. They have the odor of petroleum and are inactive to polarized light. M. Bouvier has determined their composition, their molecular weight, their density and their refraction indices and has succeeded in determining the constitution of some by converting them into known bromine and nitrogen derivatives. These observations establish the presence of the following compounds in vacuum tar:

*Saturated Hydrocarbons.* These all have the same centesimal composition corresponding to the general formula  $C_nH_{2n}$ ; they are therefore cyclanes:

$C_6H_{12}$ , boiling point 135-137 deg. (hexahydro-mesitylene)

$C_{10}H_{20}$ , boiling point 172-174 deg. (hexahydro-durene)

$C_{14}H_{28}$ , boiling point 189-191 deg.

$C_{18}H_{36}$ , boiling point 211-213 deg.

$C_{22}H_{44}$ , boiling point 227-229 deg.

$C_{26}H_{52}$ , boiling point 218 deg. at a pressure of 0.5 mm.

The last hydrocarbon is solid at ordinary temperature and is deposited with the last fraction (above 300 deg.). It crystallizes in acetone in pearly scales, melting at 62-63 deg. We have found it identical with melene which Brodie separated in 1849 from the products of dry distillation of beeswax.

*Unsaturated Hydrocarbons.* These have been isolated to date in a pure state, as dihydro-trimethylbenzene,  $C_{10}H_{16}$ , boiling at 163-164 deg., and a hexahydrofluorene,  $C_{14}H_{20}$ , boiling at 240-250 deg., and it is very probable besides that the lower fractions contain dihydrogenous derivatives of metaxylene, of mesitylene and of pseudocumene for they yielded these hydrocarbons by careful oxidation.

#### RELATION OF VACUUM TAR TO ORDINARY TAR

It is recognized that all the constituents of vacuum tar, whose nature we have been able to determine, belong to the hydro-aromatic series. The aromatic compounds of ordinary tar are replaced in our product by their hydrides. The homologs of benzene make place for those of cyclohexane and cyclohexadienes, the phenols for the alcohol, the quinoleique bases to their dihydrogenic derivatives.

It is seen that these hydrides when they are carried to a high temperature, have a tendency to lose a part of their hydrogen, to be converted into more stable aromatic compounds. It was then assumed that a phenomenon of this kind takes place in the gas retorts and that the hydrides of vacuum tar first form here and undergo with a higher temperature an immediate pyrogenous dehydrogenation. Vacuum tar would represent then an intermediate stage in ordinary tar formation.

This supposition was easy to verify by test. We took 200 g. of vacuum tar in its raw state, that is to say, not yet separated from its alcohols and bases, and caused it to run drop by drop into a red-hot iron tube,



first filled with pieces of coke (in order to realize as much as possible the conditions of the gas retort). At the other end of the tube we collected:

1—Gases (20-30 liters). These had the odor of illuminating gas and burned with a brilliant flame; they are composed of hydrogen and methane, accompanied by a little ethylene, but no acetylene.

2—Water strongly charged with ammonia.

3—A tar having the appearance and the odor of ordinary tar and from which we were able to separate benzene, toluene, xylenes, phenols, a small amount of naphthaline, anthracene and pyridic bases.

These are the principal constituents of ordinary tar. Their absence having been duly proved in the vacuum tar, the hypothesis which we have announced seems to us to be justified; the hydrogen and the methane of illuminating gas, the ammoniacal water of illuminating gas, the phenols and the aromatic hydrocarbons of tar, are not at all the immediate products of the dry distillation of coal. They are only formed at high temperatures by the decomposition of other more complex volatile compounds, and in particular the more hydrogenated ones which are formed at a lower temperature.

#### CONTRADICTION OF BERTHELOT'S THEORY OF COAL TAR

This interpretation is in contradiction with the theory of Berthelot on the formation of coal tar. It is known that the latter theory consists in admitting that upon distillation the coal is decomposed entirely into very simple products—carbon, hydrogen, water vapor, ammonia, methane, ethylene, acetylene. On contact with the cold walls of the retorts, the last of these gases, notably acetylene, undergoes a series of polymerizations and condensations which give rise to diverse aromatic hydrocarbons of tar. This is also a product of synthesis.

Berthelot has based this theory, not only on a direct study of the decomposition of coal, but on experiments of pyrogenation to which he has submitted the acetylene itself. These experiments which have been repeated recently on larger scale, but with an identical result, by M. R. Meyer at Brunswick, have established the fact that the acetylene is polymerized to a dark red and yields benzene, and that the two hydrocarbons then unite in turn to produce naphthaline and that finally it is possible to obtain by means of pyrogenated condensation of the same kind almost all of the hydrogen carbides which are found in tar.

However interesting these syntheses may be, should it necessarily be deduced that they are brought about in the gas retorts? One can only assume this, it seems to me, when it has been proved that the coal upon heating liberates great quantities of acetylene. Now this proof has not, to my belief, yet been established.

This argument would not constitute however serious objection to the theory of Berthelot even if it had been corroborated by some recent experimental facts. Perhaps it will be accepted that our study of vacuum tar supports some of these facts, and that the new explanation which I propose merits substitution in a large measure what has held up to the present time.

I say in a large measure, for my interpretation, it seems to me, ought to be applied to the major part of the reactions which take place during the distillation of coal, since this yields almost the same quantity (4 per cent) of vacuum tar as ordinary tar. However, I

realize that this does not yet account for all of these reactions. Moreover, we have not been able to discover in our tar any of the hydrogen derivatives of naphthaline. This hydrocarbon, if it exists in ordinary tar, must then have a different origin than the others, and it is highly probable that it originated through a synthetic process similar to that which Berthelot admitted. The following observation seems justified in clearing up this point. We have found that a very considerable quantity of naphthaline was formed when the vapors of cyclohexane are conducted over coke heated to redness (the vapors of benzene under these conditions yield only biphenyls). Since the cyclohexane reappears in the series of the saturated hydrocarbons which we have derived from vacuum tar, there can be seen in this reaction the source from which the naphthaline of ordinary tar proceeds.

#### RELATIONS OF VACUUM TAR TO PETROLEUM

Allusion has been made in the preceding pages to analogies that vacuum tar present to petroleum. These analogies have been noticeable not only in the physical properties of the two liquids, but also in their chemical composition. After having isolated the series of cyclanes mentioned above, M. Bouvier and I compared their properties with those naphthenes which form the essential part of certain petroleum. This comparison has shown us that the naphthenes of Baku petroleum are not identical with the cyclanes of vacuum tar. For an identical formula, they have a higher density and a higher boiling point. On the other hand, we have found a remarkable similarity between the properties of our hydrocarbons and those which M. Mabery<sup>7</sup> attributes to the naphthenes which he has derived from certain petroleum from North America (Canada and California). Table I shows the results of his investigation.

TABLE I.—RELATION OF VACUUM TAR TO PETROLEUM

| Vacuum Tar    |                                 |         |                     | American Petroleum |                                 |         |                            |
|---------------|---------------------------------|---------|---------------------|--------------------|---------------------------------|---------|----------------------------|
| Fraction Deg. | Formula                         | Density | Index of Refraction | Fraction Deg.      | Formula                         | Density | Index of Refraction Source |
| 135-137       | C <sub>9</sub> H <sub>18</sub>  | 0.7590  | 1.4212              | 135                | C <sub>9</sub> H <sub>18</sub>  | 0.7591  | Cal.                       |
| 172-174       | C <sub>10</sub> H <sub>20</sub> | 0.7765  | 1.4196              | 173-174            | C <sub>10</sub> H <sub>20</sub> | 0.7770  | 1,4149 Can.                |
| 189-191       | C <sub>11</sub> H <sub>22</sub> | 0.7838  | 1.4234              | 189-191            | C <sub>11</sub> H <sub>22</sub> | 0.7832  | 1,4231 Can.                |
| 211-213       | C <sub>12</sub> H <sub>24</sub> | 0.7862  | 1.4293              | 212-214            | C <sub>12</sub> H <sub>24</sub> | 0.7857  | 1,4289 Can.                |
| 229-237       | C <sub>13</sub> H <sub>26</sub> | 0.7953  | 1.4379              | 228-230            | C <sub>13</sub> H <sub>26</sub> | 0.7979  | 1,444 Can.                 |

It cannot be doubted in considering the results set forth in this table but that there has been found here unmistakably these identical hydrocarbons. I might add that we have separated from the last fractions of distillation of Galician petroleum a solid hydrocarbon of the formula C<sub>10</sub>H<sub>20</sub> which was shown to be identical in all its properties with the melene of vacuum tar.

We determined also the unexpected fact that we could separate from coal, by simple distillation, a series of compounds which constitute an integral part of certain petroleum. It is the first time, we believe, that there has been found a relation of a chemical nature between these two natural combustibles.

#### RELATION OF VACUUM TAR TO COAL

One point remains to be cleared up: Do the various compounds which form vacuum tar exist as such in the coal, or are they produced during the process of distillation?

<sup>7</sup>Journal of the American Chemical Society, Vol. XIX, p. 470; Vol. XXV, pp. 267 and 276; Vol. XXXIII, p. 261.

To be able to answer this question, it is necessary to revert to the methods of exhausting coal by appropriate liquids. Considerable work has already been done on this subject. Since the time of Comines de Marcilly (1862), it has been pursued almost without interruption down to the present time. Investigators have been especially concerned, however, with establishing the relative power of extraction of various solvents, and their authors have not succeeded up to the present in separating from the extracts any definite bodies of which they have been able to determine the structure or even the composition.

I have undertaken these experiments with MM. Ramseyer and Kaiser. As a solvent, we chose benzol. We then worked with small quantities of this same Mont Rambert coal, which was used in our experiments with vacuum distillation. Later, thanks to the valuable assistance rendered us by the house of F. Hoffman, La Roche and Company at Bâle, the same operation was repeated on a larger scale (with  $5\frac{1}{2}$  tons of coal); at that time, however, a Sarre coal (Maybach) was used in the work.

#### BOILING BENZOL AS A SOLVENT

In the two cases the coal, crushed in pieces the size of a pea, was treated with boiling benzol for four days in the apparatus of the Soxhlet system. The solution was immediately reduced to a strong concentrate and to it was added five times its volume of petroleum ether (boiling point 35-90 deg.). It precipitated a clear brown amorphous powder, which we have not yet studied. The solvent was then driven off by heating to 100 deg. There remained a pale brown liquid, somewhat fluid, possessing an odor of petroleum and a density exactly equivalent to 1.000 at 20 deg.

The five tons treated at Bâle yielded 2.7 kilograms of solid substance and 10.6 kilograms of liquid extractive. The yield was then 0.25 per cent.

The liquid extract obtained from the Montrambert coal was especially studied from the point of view of the less volatile substances which it might contain. Without entering into more of the details of this part of our study, I will simply say that we are able to separate the same hexahydrofluorene  $C_{12}H_{18}$  and the same melene  $C_{12}H_8$  as was found in the vacuum tar.

As to the liquid extract of the Sarre coal a large quantity of which we had on hand, we decided, on the other hand, to study its more volatile products. This extract possessed not only the odor and density of vacuum tar but also a very similar composition. It was formed, like it and in similar proportions, of saturated and unsaturated hydrocarbons and about 2 per cent alcohols and bases. In separating these bodies we proceeded in exactly the same manner as we had formerly, that is to say, by successive treatments with hydrochloric acid, sodium, liquid sulphurous anhydrides, then fractional distillation.

The definite hydrocarbons which we have isolated up to the present are given in Table II. M. Kaiser was able to determine the structure of the first three by converting them into known nitrogen and bromine compounds, and was able to establish the identity between the last three compounds and the cyclanes of the same formulas separated from the vacuum tar and the petroleum of Canada.

It is evident then that there can be extracted from the coal by means of boiling benzol (80 deg.) a series of hydrocarbons which are identical or very analogous to those yielded by vacuum distillation. This last operation then only separates them by simple volatilization, and we are safe in concluding that a part at least of the components of vacuum tar exist already formed in the coal.

They occur then as a solid hydrocarbon substance impregnated with a liquid chemically akin to petroleum. That this liquid has been formed through a slow decomposition of the solid mass, is the probable explanation, when we consider the formation of fire-damp which has been proved in all coal deposits, as well as the existence of the natural gas sources which are sometimes located in the proximity of these deposits. Fire-damp and natural gas are mixtures of hydrocarbons.

TABLE II.

| Unsaturated Hydrocarbons |               |                       |
|--------------------------|---------------|-----------------------|
| $C_7H_{10}$              | boiling point | 108-110 deg.          |
| $C_8H_{12}$              | boiling point | 135-137 deg.          |
| $C_9H_{14}$              | boiling point | 166-168 deg.          |
| $C_{10}H_{16}$           | boiling point | 180-182 deg.          |
| $C_{11}H_{18}$           | boiling point | 200-202 deg.          |
| $C_{12}H_{20}$           | boiling point | 236-238 deg.          |
| $C_{13}H_{22}$           | boiling point | 251-254 deg.          |
| $C_{14}H_{24}$           | boiling point | 251-254 deg.          |
| $C_{15}H_{26}$           | boiling point | 251-254 deg.          |
| Saturated Hydrocarbons   |               |                       |
| $C_8H_{18}(?)$           | boiling point | 118-122 deg.          |
| $C_9H_{20}(?)$           | boiling point | 135-138 deg.          |
| $C_{10}H_{22}(?)$        | boiling point | 172-174 deg.          |
| $C_{11}H_{24}$           | boiling point | 190-192 deg.          |
| $C_{12}H_{26}$           | boiling point | 215-216 deg.          |
| $C_{13}H_{28}$           | boiling point | 227-229 deg.          |
|                          |               | Dihydro-toluene       |
|                          |               | Dihydro-metaxylene    |
|                          |               | Dihydro-mesitylene    |
|                          |               | Dihydro-prelnitol (?) |
|                          |               | Dihydro-fluorene (?)  |

The analysis gave us figures a little too high as to hydrogen content, thus indicating the presence in slight amounts of hydrocarbons of  $C_nH_{2n+2}$  formula.

Identical in every respect with the hydrocarbons of the same formula obtained from vacuum tar and petroleum from Canada.

It is possible to conceive that near these gaseous products the spontaneous decomposition of coal could form from them others of the same chemical nature but which at the surrounding temperature are liquid and slightly volatile. They would remain necessarily embedded in the solid mass, from which vacuum distillation or even a simple washing with benzol could separate them.

We could go even farther and couple the origin of actual petroleum deposits to a decomposition of this kind which will come in due time. But this idea meets with numerous objections of a geologic nature. Its discussion in the present state of our knowledge would be premature. I prefer then not to touch upon this point here, and to limit myself to this short resumé of the experimental research which my co-workers and I have done on the coal itself. I believe it to be my duty to refrain for the time being from considering the industrial applications which our methods may receive. They will appear better when our research has become further advanced.

**The Natural Indigo Industry.**—With the cutting-off of the supplies of synthetic indigo from Germany since the outbreak of war, the cultivation of natural indigo has increased considerably. While the total area under this crop in 1914-15 was only 148,400 acres, in 1915-16 it rose to 353,100, and in 1916-17 to 756,400 acres. The greatest increase, both relative and absolute, occurred in the Madras Presidency and in the United Provinces, where the industry is mainly in the hands of small holders, and the dye manufactured is of an inferior quality.

# CHEMICAL & METALLURGICAL ENGINEERING

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### Increasing Production of American-Made Potash

ACCORDING to the figures given out by the U. S. Geological Survey, the production of potash for the first half of this year was between 20,000 and 25,000 tons of  $K_2O$ , and it is estimated that the total for the year will reach 60,000 tons, as compared with 32,575 tons in 1917. This is about 25 per cent of our pre-war importations, and if this country is to become independent of Germany, immediate steps should be taken to further develop our own sources of supply. The cement works and blast furnaces alone should be able to supply our total requirements, but so far these industries have done very little. By the end of 1918 about a dozen cement companies will be recovering potash as a by-product, and incidentally abating the dust nuisance. The blast furnaces are doing practically nothing although it is generally recognized that they would benefit considerably by obtaining cleaner gas for the stoves and gas engines. The manufacturers can hardly be blamed for not putting money in the necessary additions to their plants under the present uncertainty of the whole potash question. Although the present prices are high, no one knows how long they will last, and under the proposed revenue bill most of the profits would be taken by the government as taxes. The manufacturers would not object to this if they were allowed to amortize the cost of plant before being subject to any profits tax. The producers of potash should also be given definite assurance by the government that there will be no "dumping" of German potash after the war.

A source which it seems to us should be thoroughly investigated is the potash-bearing silicate rocks. There are large deposits of these running fairly high in potash, notably the greensands of New Jersey, the leucite deposits of Wyoming, and the sericites and potash-bearing states of Georgia. Although no commercially successful method of extracting potash from silicate in general has as yet been developed, this problem should not be beyond the skill of American chemists and metallurgists. Congress granted an appropriation of \$175,000 in 1916 to the Department of Agriculture for an experimental plant for treating kelp, and it seems to us that the silicates offer an even more promising source of potash. We think it would be a very good idea if a similar appropriation were made to the Bureau of Mines for carrying out experiments on these silicates, as if a successful process of extracting the potash can be developed, the supply of raw material is practically unlimited.

Our recent editorial comments on the advisability of



searching iron ores and fluxes are ably supported by the article of Mr. Grasty on "Potash as a By-product," published elsewhere in this issue. The author makes a timely point when he avers that our future production of potash must compete with the German product, and that we must consequently rely on cheap sources of supply. By-product sources usually are inexpensive. The cement industry is already doing something in this line, and the blast-furnace must support in larger measure the production of the cement kiln.

### The Evaporation of Weak Liquors.

MANY chemical and metallurgical processes are broken by the cost of evaporating large quantities of weak solutions. Others are more fortunately situated as regards the price of heat or the relative quantity of liquid to be removed. In any case, men who are responsible for the evaporating practice in scores of chemical processes should find much of interest in the article published in this issue on "A Wet Process for Extracting Potash from Cement Dust," in which is described a rather unique condenser-evaporator installation. Briefly, this particular process required the production of a very humid gas, the cooling of this gas approximately to atmospheric temperature, and the collection of its precipitated mist. The practical operation developed a method of conserving furnace energy far beyond the power of the ordinary waste-heat boiler, and apparently applicable to many processes—at least meriting most careful consideration.

Conventional evaporating practice involves the production of large quantities of live steam by the most efficient boiler practice, and the utilization of the latent and sensible heat of the vapor in multiple-effect evaporators. Boiler gases escape at a temperature well above that of the steam produced, and usually carry with them large amounts of heat which go to waste except for the production of draft. Mr. Dean's process takes such gases, reduces them to temperatures but little above the atmosphere, and utilizes the abstracted heat for evaporating purposes. Indeed, it might prove to be more profitable to throw more work on the condenser-evaporator unit, and less on the boiler by eliminating any economizers, which by the way, are often regarded by their possessors as diluted blessings.

### Outlook for German Competition in Potash

AT THE potash symposium yesterday Mr. Linn Bradley sounded a note of warning against the danger of national lethargy in recognizing the importance of potash independence. He also pointed out the certainty of German competition after the war and called for national support of the domestic potash industry. His sentiments coincide with those of others who have given the subject consideration, and we are glad to give them publicity in these columns in view of the importance of the matter.

"It seems ridiculous that the United States should be playing the rôle of food granary for ourselves and our allies, also raising the cotton which is so necessary in connection with the war, and yet nothing is being done to provide the potash either for food purposes or for the

cotton, except the limited and inadequate efforts due to private initiative. It ought to be emphasized that potash is a subject which should be understood and appreciated by everyone in the nation, and that it should be considered primarily from the national point of view. Does any one of us imagine that there is such ignorance of potash in Germany as exists among our own citizens? No, they have learned that potash is the big German raw-material and economic weapon which they counted upon and are still counting on to help the Kaiser impose his will on you and on me.

"To all those who are assisting in the solution of the problem, I would state that we should soon take steps to solve our post-war problems. The question of the market conditions which will prevail is ever before us. Germany will do all within her power after peace is declared to break down that which will have been built up, the same as she has destroyed the beautiful cities of France. She will endeavor to regain control of the potash situation in this country. Even now she probably has her propaganda all prepared and ready for launching. One need not be surprised to learn that she has agents in the various Governmental departments and bureaus in Washington ever ready to interfere with efforts being made by our technical and business men. Even now we hear rumors to the effect that potash is not a plant food and is not needed for cotton, potatoes and various other crops. Careful investigation of the southern cotton fields should be convincing that this may be another piece of German propaganda. It is difficult to check up these rumors, but all of us should be on guard against them.

"It would be to the national interest in the broadest way for this country to take steps to forever exclude every ounce of German potash. Tariff, price control and other methods should be earnestly considered. The farmer must be made to realize that he dare not use German potash even if he might obtain it a little bit cheaper than the local product. In other words he must not be a potash slacker. The politician hates to take any action which would have a harmful effect on the farmer vote, so we may look for strong opposition when legislation is urged for protection of the new potash industry. It would be shortsighted if our Congressmen should fail or neglect fully to protect this industry. It should be remembered that Germany will continually strive to break down any barriers which may have been erected, and it therefore behooves us to band ourselves together in an alliance which could fittingly be called the American Potash Alliance and see to it that our interests are at all times being taken care of.

"In unity there is strength, therefore let all parties interested form such an alliance and immediately organize and institute efforts to have the proper legislation passed, and also to conduct a publicity and an educational campaign throughout the country and, generally, to serve the combined interests of those who assist in rendering our country free from the Kaiser as far as potash is concerned. The hearty and active coöperation of the various technical societies should be readily obtained, and I commend these suggestions for the formation of the American Potash Alliance to their attention."

## Sidelights on the Exposition

The New Jersey Zinc Co. has a bull's eye on its drawn zinc rods and wire. This is made of very pure metal and, as shown by the exhibit, it machines well and may be turned and used for fittings of various kinds in the place of brass. It may be polished and lacquered, but if this surface will not do, they even show a sample of it that has been gold-plated. Little difficulties should not stand in the way of progress. Another way to avoid the use of brass as displayed by this company is by sherrardizing small iron castings such as are used in building hardware. Another N. J. zinc bull's eye is on zinc oxide, U.S.P., now made in large quantities for the first time in this country.

\* \* \*

Another metal-saving possibility is shown by the National Gum & Mica Co. in a method of coating paper containers with a colloidal solution of tin and afterward burnishing it into a very thin colloidal film. The back of the paper is coated with paraffin to augment its merit, and the front looks like tin. Still another new thing is a high-speed gum whereby long paper cylinders may be turned out by machinery without the usual gooev difficulties, and these are then cut into desired lengths for boxes. And another bull's eye is attached to Mr. Jerome Alexander's new colloidal silver which will doubtless find its main use as a drug, in the treatment of diseases of the mucous membranes. For certain of these, silver in a very finely divided state seems to be a specific. If applied in the form of silver nitrate or in its presence, an artificial membrane or coagulum is produced over the places where the micro-organisms have bored themselves in and where they proceed unharmed in their nefarious business. It appears that this defect has been overcome in Mr. Alexander's invention.

\* \* \*

The grape-juice girls are on hand again, all over the Palace, selling the beverage at ten cents *per*, in sterilized paper cups. It is excellent grape juice, and we observed but two criticisms upon it among all the thousands present. One was from a stout, red-faced man who declared, as he stood drinking it, that it had an "unfinished" taste. If it had been finished as he desired it we are convinced that the internal revenue officers would soon have been worrying the girl that sold it. The other criticism was by example rather than by precept: across the way from the stand is the booth of the Celite Products Co. where samples are shown in pairs, to exhibit various products before and after filtering through their filters. These include lemon oil, soap, lye, kola tonic, molasses, apple cider, castor oil AND grape juice among many other things. The clear, ruby, filtered grape juice serves well the purposes of the exhibitors, but we have no faith in its appeal to the stout man with the red face. No amount of filtering would give it the "finish" that he desired.

\* \* \*

The American masks have the merit of being effective against lethal gas even when the face-piece is torn or cut, although in this event of course the soldier would not be immune against torture gases.

A Freudian philosopher was observed contemplating the U. S. Army mask for horses. "Here we see," he

exclaimed, "the evidence of a wish on the part of the designer which is apparent to every true Freudian. He wanted to be in the woods, hunting big game, instead of doing the work in hand, because he has unconsciously made the horse to resemble a moose!" There certainly is nothing like Freudian philosophy for boring into the other fellow's soul!

\* \* \*

The chemical-warfare exhibit is distributing "literature," which means copies of rules and general orders relating to chemists and engineers in essential industries. It will surely be a great convenience to manufacturers who are so engaged because here they may obtain concrete information. The orders are very direct and simple: they are written to be understood and obeyed, and not quibbled over. There are rules for the allocation of enlisted men to industry, which means getting men out of the ranks and back into the works. It can be done but it isn't easy and it doesn't look profitable to undertake unless the industry is "essential to the prosecution of the war," and the man's work cannot be done by any other man or woman. It doesn't seem so many years ago when the most dreadful thing that could happen was the loss of money to a corporation. The War Department does not seem to consider it in this light. What mustn't happen is keeping men out of the army without good and sufficient reasons.

Many men are needed in industry far more than they are needed in the ranks, and yet they feel ashamed not to be in the army. They want to feel that they are in the fight and in it with a gun. Sometimes an impelling reason for their unrest has been that when they returned home and went to work again in the factory they were called slackers. Instructions, therefore, have been issued for men on indefinite furlough, when such furlough is granted for periods to exceed three months, that the regulations as to uniform shall be the same for them as for honorably discharged enlisted men. They are authorized but not required to wear the service uniform, but it shall be furnished and maintained without expense to the United States. They must not wear it, however, while performing manual labor.

This rule sounds pretty good to us. If men are teased for not being on the firing line they can put on their uniforms and stand forth in them in all the dignity of a soldier of the United States.

\* \* \*

Of course, everybody knows how to run a bank, a railroad or a newspaper. This is confirmed by the frequent criticisms of banks, railroads and newspapers that we hear on all sides from nearly everybody, with specific details as to what should be done that it left undone and wherein capital errors lie. And yet, there are little details in banking that require study and experience — just as we find this need in chemistry. So the Irving National Bank of New York has taken a booth at the Exposition and Mr. Dimse, their representative, says that it bids fair to be abundantly worth while. The inquiries in regard to banking facilities, more particularly as to export trade, are frequent and sincere, and opportunities to get posted in regard to acceptances, foreign exchange and a considerable series of other subjects are provided for by numerous pamphlets issued by the bank.

## From A to Z With the Exhibitors

**AIR REDUCTION CO.** An exhibit of compressed oxygen, acetylene, nitrogen, hydrogen, gas welding supplies, ammonia, cyanides, formates, ferro-cyanides, Paris blue and Turnbull's blue. In charge of exhibit: R. T. PEABODY, MISS L. E. MARRS.

**ALBERENE STONE CO.** Complete chemical laboratory hood, the superstructure of hood being Alberene stone; table top, reagent shelves and sink. In charge of exhibit: A. Y. MEEKER, W. K. FIELDS, N. N. MONEY-PENNY, R. J. NYCE.

**AMERICAN PIPE BENDING MACHINE CO.** A Model S Junior and a Model A standard "Wonder" pipe bending machine. In charge of exhibit: E. P. BLAKE.

**ANACONDA COPPER MINING CO.** An exhibit of copper bars, cathod, anode billets, sulphate and blister copper together with selenium, tellurium, nickel sulphate, zinc and silver. In charge of exhibit: S. SKOWRONSKI.

**H. REEVE ANGEL & Co., INC.** Whatman analytical and American industrial filter papers; Labruco rubber tubing. In charge of exhibit: ERNEST CHILD.

**ANTI-HYDRO WATERPROOFING CO.** A non-corrosive concrete waterproofing. In charge of exhibit: M. D. HAUSLING.

**BACHMEIER & Co.** Dyestuffs as follows: Congo red, aniline black, patent blue; Baco direct rose and pink, which is fast to acid; acid fast red, direct yellow, methyl violet, direct blue, sulphur black, sulphur khaki and chrysophenine. In charge of exhibit: E. J. STRUCK, MARSDEN LORD.

**J. T. BAKER CHEMICAL CO.** Laboratory analysed chemicals, organic acids, barium, copper, cobalt, ferric lead, magnesium, manganese, nickel, potassium, sodium salts, etc.

**THE BARBER ASPHALT CO.** Samples of Genasco roofing, shingles, mastics, waterproofing, paints and varnishes, Genasco asphalt putty, Genasco mineral rubber, Trinidad and Bermudez Lake asphalts, Gilsonite, acid-proof mastic tank linings. In charge of exhibit: E. J. CARLEN, A. S. LEWIS, THEODORE THOMAS.

**THE BARRETT CO.** An exhibit of the Chemical Department which includes coal tar products, toluol, ammonia, paracumaron resins, phenol, benzol, cresols, pyridin, naphthalin, resorcin, B.R.C. rubber filler. In charge of exhibit: H. G. SIDEBOTTOM.

**BOYER OIL MFG. CO.** An exhibit of oils, including cottonseed, castor, soya bean, peanut, sesame, cocoanut, rape seed, palm kernel, china wood, palm, poppy seed and all oil cakes. In charge of exhibit: W. G. REED.

**BROWN INSTRUMENT CO.** Thermometers and recording gages. They will exhibit specially encased instruments which are protected from fumes, dirt, etc. In charge of exhibit: GEORGE W. KELLER.

**BUFFALO FOUNDRY AND MACHINE CO.** An extensive exhibit showing expansion tanks, evaporators, nitraters, vacuum dryers, vacuum pumps; high concentrator, vertical tube evaporators; horizontal tube evaporators and rapid circulation evaporators. In charge of exhibit: E. G. RIPPEL.

**CANADIAN ELECTRODE CO.** Carbon electrodes.

**CANADIAN ELECTRO PRODUCTS CO.** Acetic acid, acetaldehyde, paraldehyde, acetone, sodium acetate, mercuric oxide.

**CELITE PRODUCTS CO.** Filter-cel, sil-o-cel, high-temperature insulation, and celite, also samples of clarified oils. In charge of exhibit: W. S. COLLINS.

**CHEMICAL PUMP AND VALVE CO.** Lead and stoneware pumps. In charge of exhibit: F. A. WARTER.

**CONSOLIDATED COLOR & CHEM. CO.** Gallocyanine (fast navy blue), sulphur dyes, chrome dyes. In charge of exhibit: H. A. METZ.

**CONTACT PROCESS CO.** Sulphuric acid, 50 deg., 60 deg. and 66 deg.; oleum, 20 per cent; nitric acid, muriatic acid, salt cake and niter cake.

**CORNING GLASS WORKS.** Laboratory glassware, Pyrex and colored signal light glassware. In charge of exhibit: G. W. DRAKE.

**CRANDALL PETTEE CO.** Gas and electric automatic baking and drying ovens. In charge of exhibit: PAUL DELANY.

**CRESCENT INK & COLOR CO., INC.** An exhibition showing how ink is made. In charge of exhibit: N. A. MCMANUS, JOSEPH M. PETRY, WALTER A. CONLAN.

**DOW CHEMICAL CO.** Samples of chemical products manufactured by the company. Since entering the war this company has developed and perfected on a large scale the process of synthetic indigo 20 per cent, paste and dibrom-indigo 20 per cent. paste. The product is pronounced equal in every way to that imported from Germany before the war. Diethylaniline is also being manufactured on a commercial basis.

**DUPONT & Co.**—The space occupied by the duPont Company is the largest ever occupied at the Chemical Exposition. The exhibit shows most of the 300 products made by the company. For the first time there is displayed a rather complete lot of dyes which have been manufactured during the past year. The Arlington Works division exhibits a line of high-class toilet articles made from ivory pyralin. In charge of exhibit: R. L. VILAS, STANLEY F. WHITE, J. A. GWYN.

**DURIRON CASTINGS COMPANY.**—A line of pumps, cocks, valves, pipe, kettles, exhaust fans, nitric acid condensers, bleacher pots, denitrating towers and Hough sulphuric acid concentrators. The latter has been on the market since the United States entered the war. It is built along entirely new lines and is applicable to most processes where evaporation is required. In charge of exhibit: J. R. PITMAN.

**EDISON INTERNATIONAL CORPORATION.** Coal-tar products; chemicals; drugs. Paraphenylenediamine is featured in the exhibit. In charge of exhibit: T. C. LEMLEY, J. D. LYMAN, W. C. WETMORE, E. P. MOUSIR.

**THE ELECTRIC FURNACE CO.** Exhibition of photographs and drawings of furnaces that are producing war materials, such as airplane parts, billets for shells, melting furnaces for airplane and submarine castings. In charge of exhibit: D. D. MILLER.

**ELECTRO BLEACHING GAS CO.** Manufacturers of liquid chlorine. In charge of exhibit: J. A. KIENLE, D. K. BARTLETT.

**ELECTROLYTIC ENGINEERING CORP.**—The Wheeler process for the manufacture of caustic soda and liquid chlorine will be exhibited by means of photographs and cross-sectional views to show the details of the cell and process. In charge of exhibit: R. G. KEHOE.

**ELECTROLYTIC ZINC COMPANY.** An exhibit of zinc





products. In charge of exhibit: S. G. SCHATZBERG, A. W. HAHN, W. H. NAUGLES.

**ELECTRON CHEMICAL CO.**—A complete cell for the electrolytic production of chlorine and caustic soda, together with photographs illustrating some installations. In charge of exhibit: HERBERT I. ALLEN.

**G. H. ELMORE.**—Acid-proof centrifugal pumps, with blueprints showing interior arrangement. Blueprints of centrifugal driers. **BLAIR CAMPBELL & MCLEAN, LTD.**, from Glasgow, Scotland, are associated with Mr. Elmore in this exhibit, but on account of the scarcity of cargo space it has been impossible to secure specimens of their chemical apparatus for exhibition purposes. In charge of exhibit: G. H. ELMORE, R. W. RIGLER, A. C. WOOD, For **BLAIR, CAMPBELL & MCLEAN, LTD.**, JAMES C. LAWRENCE.

**ELYRIA ENAMELED PRODUCTS CO.**—Elyria cast iron glass-enameled equipment, including a 125-gallon still, 125-gallon open jacketed kettle, 35-gallon kettles, 2-gallon stills and autoclaves. Practically all of the cast iron apparatus has been developed since the beginning of the war, due to the great demand occasioned for such apparatus formerly furnished by foreign makers. In charge of exhibit: WM. E. GRAY.

**EMPIRE CHEMICAL CO.**—This exhibit consists mainly of saccharine. In charge of exhibit: S. J. NATHAN.

**EMPIRE LABORATORY SUPPLY CO.**: Glass apparatus manufactured at Vineland, N. J. This company is making glass apparatus which formerly came from Germany. In charge of exhibit: PHILIP FREEDMAN, M. A. GOLDSTEIN.

**EVERLASTING VALVE CO.**—"Everlasting" valves in all sizes from 16 in. to 1 in., arranged in pyramid about 40 in. diameter at the base and extending 13 or 14 ft. from the floor. Everlasting tandem valves. In charge of exhibit: EDWARD N. CORNING.

**W. L. FLEISCHER & CO., INC.**—Small-scale model of a warm moist air dryer, built especially for the drying of chemicals, fruits and vegetables. This will be an exact model, complete in every detail. It has been developed entirely since our country entered the war. In charge of exhibit: R. E. KEYES, A. W. LISSAUER.

**FOOTE MINERAL CO.**: Various mineral products and their derivatives as well as ores and compounds of the rarer elements including zirkite, antimony trisulphide, manganese dioxide, zirkite bricks, cerium-iron alloy, ammonium molybdate and molybdic acid, strontium sulphate, titanellow colors and zirkonalba. A feature of the exhibit is the projection of bright line and absorption spectra of the rare element salts, as well as processes of crystallization. In charge of exhibit: H. C. MEYER.

**FOXBORO CO., INC.** A temperature controller, CO. recorded and recording pyrometer all in operation; recording hydrometers, planimeters, time recorders, gage boards with instruments, CO. recorders, indicating and recording thermometers; gages, pressure, syphon, mercury, vacuum and liquid level; pyrometers; revolution counters. In charge of exhibit: W. W. PATRICK, M. B. HALL, L. H. DUPAUL.

**FULLER-LEHIGH COMPANY.** A model of the Fuller-Lehigh pulverizer mill, with samples of chilled charcoal iron castings for abrasive resistance. In charge

of exhibit: C. R. RINEHART, E. H. FROMM, W. A. STURBLEBINE, G. D. MEASE, P. F. STUFFER.

**CHAS. F. GARRIGUES CO.**: A display of chemicals and special exhibits of caustic potash, stearate of zinc and sulphur dioxide. In charge of exhibit: OTTO F. ANDERSON and other representatives.

**GENERAL BAKELITE CO.**—Bakelite raw materials and finished products made from same. The raw materials include moulding material, lacquer, varnish, cement and enamel. The finished products show a wide range of mechanical and electrical articles made from various bakelite moulding materials. The application of lacquer, protective enamel and cement is also shown. Bakelite rods, sheets and tubes manufactured from bakelite canvas and paper is featured in the exhibit. Numerous other articles are shown which have become more or less well-known to the general public, such as pipe-stems, umbrella handles, fountain pens, etc. In charge of exhibit: HYLTON SWAN.

**GENERAL CERAMICS COMPANY**—Armored stoneware centrifugal pumps, armored stoneware exhauster, machine for etching copper plates by nitric acid, stoneware automatic acid elevator. In addition to the foregoing which will be shown in operation, there will be a model of the Valentiner nitric acid installation which has been adopted by many of the belligerent countries, as well as many of the large industrial concerns here and in Europe. All of this material has been developed in this country since the war for the first time. In the exhibit will be one of the largest stoneware vessels ever manufactured in this country, although not the largest manufactured by this company. There will also be miscellaneous stoneware equipment, a new tower filling, and a variety of small shapes for high-temperature work. In charge of exhibit: PERCY C. KINGSBURY, F. A. WHITAKER, K. J. PETERS.

**GENERAL CHEMICAL COMPANY**—Commercial and C. B. acids and ammonia, reagents, acetyl chloride, copper sulphate, iron salt, lead acetate, magnesium sodium and tin salt, zinc sulphate, "Orchard" brand of insecticides and fungicides, and "Lariat" brand cattle dips, and "Ryzon" baking powder. In charge of exhibit: N. PETERKIN and members of sales staff.

**GENERAL ELECTRIC COMPANY**—Flow meters for measuring steam, water, air, oil and gas. A long list of processes and commodities relating to the chemical industry, developed in the company's research laboratory. The diversity of the activities of the laboratory is indicated in the variety of the exhibit, which covers improved lighting, radio apparatus, searchlights, X-ray apparatus, Coolidge tubes, water japsans, metals, alloys, chemical compounds and smoke precipitation. In charge of exhibit: L. W. SHUGG and other representatives of the company.

**GENERAL FILTRATION COMPANY**—Filtros plates in various sizes, grades and shapes, being uniformly porous and acidproof, are finding extensive use in the chemical industry. The porosity of the material will be demonstrated by forcing air through a plate which has been saturated with water. Electro-filtros, a porous acidproof diaphragm, will be exhibited in electrolytic cells of various sizes. In charge of exhibit: F. E. LEIBY.



## Potash from Searles Lake\*

An Account of the Development of a Project for the Recovery of Potash from the Saline Water of a California Lake—The Product Contains Sixty-Five Per Cent Potassium Chloride

By ALFRED DE ROPP, JR.

Research Engineer American Trona Corporation

FOR the following topographical description of the Searles Lake Basin and its porous salt bed, I am indebted to *Bulletin 580-L*, written by Hoyt S. Gale of the United States Geological Survey.

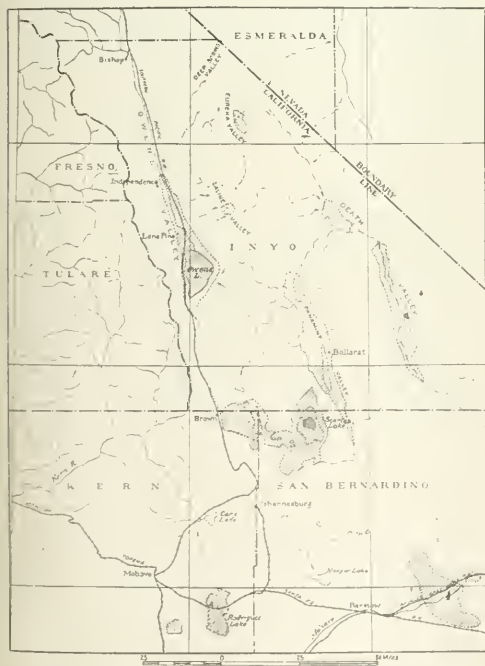


FIG. 1.—MAP OF THE CALIFORNIA SALINE LAKES

His description of Searles Lake and the surrounding country is the clearest and most comprehensive of

any that have come to our notice. Fig. 1 shows the location of California saline lakes, and Fig. 2 their respective elevations.

Searles Lake Basin is a broad, roughly circular valley or depression eight to ten miles from east to west and twenty to twenty-five miles from north to south, bordered by the abruptly rising slope of the surrounding ranges. This basin lies between the Argus Range on the west and northwest, and the Slate Range on the east; the latter a narrow, rocky wall, which divides it from the larger and deeper depression of the Panamint Valley.

The Searles Lake Basin was, during a part of the glacial epoch, occupied by at least one deep lake, whose traces are still so distinct as to be indisputable.

While the waters stood at their highest position the Searles Basin was flooded to a depth of 635 to 640



FIG. 2. PROFILE SURVEY CROSSING LAKES

feet above the level of the present valley bottom, and the lake extended back through the Salt Wells Valley to join with a broad, shallow lake that flooded the greater part of the Indian Wells Valley.

With the lowering of the water-level less than seventy-five feet, the divide in the volcanic peaks between Indian Wells Valley and Salt Wells Valley became an actual division between two distinct water bodies, and for a time here also there was a period of overflow from Indian Wells Valley to the lower waters in the Searles Basin, in the same way that Owens Valley overflowed and spilled its waters into Indian Wells Lake. These are facts attested to by the records of the ancient shore lines and water channels.

The determined elevation of the lowest part of the present salt flat in the main Searles Basin is 1,617.6 feet above sea level.

\*A Paper read at the Fourth National Exposition of Chemical Industries, New York, Sept. 25, 1918.



The Owens Lake, during a period of former greater water supply, overflowed the divide at the south end of its basin and its surplus waters flooded in turn a succession of lower basins, of which the Searles Basin was one of the largest.

The Owens waters, after passing the Haiwee Divide, dropped some fifteen hundred feet in about thirty miles to Indian Wells Valley, and then spread out in a broad and relatively shallow sheet of water. This, in turn, also overflowed, its waters passing by way of Salt Wells Valley and a rock cut gorge at the lower end of that valley into the Searles Basin.

Eventually, the waters rose in the Searles Basin to

level of the brine in the lake at any one spot to a noticeable extent.

The main or central salt deposit is a firm but extremely porous bed of salt crystals, so hard and compact that roads are built on it, teams and motor trucks have no difficulty in driving over its surface, and even the concrete foundations of the American Trona Corporation's pump house were laid on the surface of the crystal body.

The first fifteen to twenty feet of the crystal body is composed of cubical halite and will analyze 90 per cent (or better) NaCl on a dry basis. Below this are alternating and irregular layers of salts, respectively

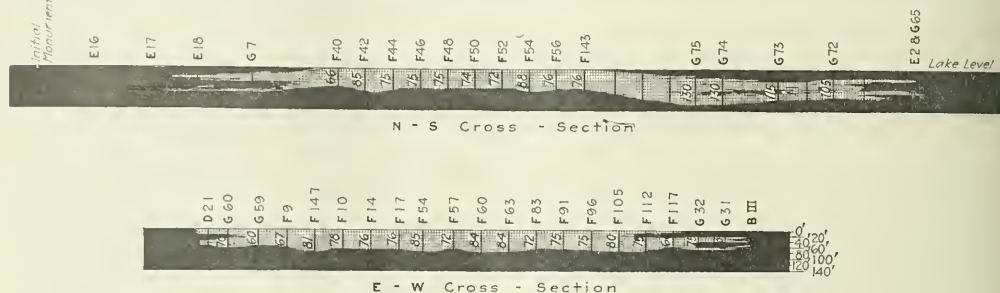


FIG. 3.—CROSS-SECTIONS OF SEARLES SALT DEPOSIT

such a height that all three of these valleys were submerged in one continuous body of water. The maximum water level in this basin was clearly determined by the elevation of an outlet pass on the south side of the basin, whence its surplus waters flowed into the extreme south end of Panamint Valley.

In the Panamint Basin a history similar in some respects to that of the Searles Basin was repeated. The waters rose until the height of the lowest outlet was reached, and as they evidently remained stationary at about that level for a relatively long period, it is presumed that this level was determined by the overflow of its surplus waters.

#### SALT DEPOSIT PROSPECTED BY DRILLING

The most distinctive feature of this desert basin is the immense sheet of solid white salts that lie exposed on its bottom. It is to this salt deposit that the name Searles Lake has been generally applied. So far as known, at present the deposit is unique in this country in the variety of its saline minerals.

Fig. 3 shows two cross sections of the crystal body. These were plotted from data obtained from the numerous wells which were drilled by the California Trona Company to comply with the assessment work necessary to hold its claims. Some 300 wells were thus drilled.

As may be seen, the crystal body underlies the surrounding mud flats found along the shores of Searles Lake.

The area of salt crust in the Searles Basin is some twelve square miles in extent, and averages from 65 to 75 feet in depth. The formation of the crystal body is such that the brine with which it is associated is absolutely free-flowing, and nowhere, even by extended pumping operations, have we been able to lower the

high in trona, a sesquicarbonate of soda, sodium chloride, and sodium sulphate. The potash content of these layers is very irregular, layers of potash bearing crystals having been discovered by various drilling operations, which ran from fourteen to thirty-odd per cent potassium chloride. (The average potash content of the crystal body is roughly 4 per cent potassium chloride.)

In a report made to the American Trona Corporation by Charles S. Lee it is estimated that the crystal body contains 110,000 million gallons, or 594,000,000 tons of brine. This does not include any incoming waters from either underground or surface sources. This brine will average 4 per cent potassium chloride. The potash contained in this brine amounts to 23,760,000 tons of potassium chloride.

The average brine pumped by the American Trona Corporation has the composition given in Table I.

TABLE I—AVERAGE COMPOSITION OF BRINE

|                 | Per Cent |
|-----------------|----------|
| Na              | 11.00    |
| K               | 2.50     |
| Cl              | 12.50    |
| CO <sub>2</sub> | 2.65     |
| NO <sub>3</sub> | 4.65     |
| B               | .35      |

In view of the process in use, the brine is given the arbitrary composition shown in Table II based on the values in Table I.

TABLE II—COMPOSITION OF BRINE BASED ON VALUES IN TABLE I

|                                               | Per Cent            |
|-----------------------------------------------|---------------------|
| NaCl                                          | 16.50               |
| Na <sub>2</sub> SO <sub>4</sub>               | 6.90                |
| Na <sub>2</sub> CO <sub>3</sub>               | 4.70                |
| Na <sub>2</sub> B <sub>4</sub> O <sub>7</sub> | 1.50                |
| KCl                                           | 4.75                |
| Specific Gravity                              | 1.290 at 30 deg. C. |

All the CO<sub>2</sub> is figured as normal carbonate, although the brine contains some bicarbonate. This brine is pumped to the plant from wells drilled in the crystal

body of Searles Lake. The brine is pumped to storage tanks and from them directly to the evaporators. It passes first through a 16-foot Manistee vacuum pan, which is used merely as a pre-heater. From this it is pumped to three 22-foot pans of the same type, which are operated in triple effect.

The pans handle from 200,000 to 250,000 gallons of raw brine and about 100,000 gallons of mother liquor



FIG. 4.—PUMP HOUSE BUILT ON SALT DEPOSIT

per twenty-four hours. This total of 300,000 to 350,000 gallons of liquor is concentrated to about 100,000 gallons of "concentrated liquor" before being sent to the crystallizing house to cool.

During the boiling, sodium chloride, sodium sulphate and sodium carbonate are salted out. These tailing salts drop to the bottom of the vacuum pans and are removed by salt elevators of the regular Manistee type. The elevators discharge their salts into waste salt cones from which they are washed away by water.

Machinery is being installed by Dr. H. W. Morse, technical manager for the corporation, by which we will recover 95 per cent of the potash formerly carried away by these waste salts. This will increase our output by some ten tons (or better) of potassium chloride per unit per twenty-four hours. Operating under the old system this was previously lost to us.

EVAPORATION AND CRYSTALLIZATION

The liquor in the pans is boiled down to the point where potassium chloride begins to salt out, and is then sent to crystallizing vats in this condition at a temperature of 90 to 95 deg. C.

The temperatures and vacua are about as follows:

| Pan No. | Vacuum, In. | Temp., Deg. C. |
|---------|-------------|----------------|
| 4 ..... | 24.5        | 50-55          |
| 3 ..... | 24.5        | 50-55          |
| 2 ..... | 21.0        | 70-75          |
| 1 ..... | 12.5        | 90-95          |

The triple-effect pans are operated with constant flow, liquor entering the pan next the vacuum pump (where the vacuum is highest and the boiling point lowest) and passing in a constant flow from this pan through

the intermediate pan to the final high-temperature, low-vacuum pan, and from this pan to the crystallizing vats.

Cooling and crystallization take place in crystallizing vats 54 by 15 by 6 feet. There are 36 such vats in the unit now operating, and the day's run of hot concentrated liquor fills from three to four of these. The vats cool for about eight days, and the liquor, now nearly at atmospheric temperature, is then drained off.

The crystal crop is shoveled into a traveling box and is carried to a drain floor, where it is allowed to lie for about a week or so before shipment.

COMPOSITION OF RAW MATERIAL AND PRODUCTS

Table III gives the average composition of raw brine,



FIG. 5.—ROAD CROSSING SALT DEPOSIT

concentrated liquor, mother liquor returned to the system, and crude potash salts ready for shipment:

TABLE III.—PERCENTAGE COMPOSITION OF RAW MATERIAL AND PRODUCTS

|                                                     | Raw Brine | Concentrated Liquor | Mother Liquor | Crude Potash Salts |
|-----------------------------------------------------|-----------|---------------------|---------------|--------------------|
| Na <sub>2</sub> B <sub>4</sub> O <sub>7</sub> ..... | 1.50      | 8.81                | 7.82          | 10.91              |
| Na <sub>2</sub> CO <sub>3</sub> .....               | 4.70      | 10.82               | 10.53         | 1.70               |
| NaCl .....                                          | 16.50     | 9.67                | 9.43          | 10.93              |
| Na <sub>2</sub> SO <sub>4</sub> .....               | 6.90      | 2.58                | 2.08          | 0.44               |
| KCl .....                                           | 4.75      | 14.87               | 10.82         | 66.34              |
| H <sub>2</sub> O .....                              |           |                     |               | 9.66               |
| Total .....                                         | 34.35     | 46.75               | 40.68         | 99.98              |
| Sp. Gr. at .....                                    | 1.290     | 1.384               | 1.362         |                    |
| Temperature, Deg. C .....                           | 30        | 38                  | 34            |                    |

The American Trona Corporation is producing to date some 1800 tons of crude potash salts a month. Additional equipment, such as a nearly completed second unit, together with a 300-ton ice plant for refrigerating purposes and new methods for treating the concentrated liquor (devised under the direction of Dr. H. W. Morse) will enable the American Trona Corporation to produce by the end of October some 4500 tons

of potash salts a month, analyzing from 75 to 80 per cent potassium chloride and containing less than 3.5 per cent borax, figured as anhydrous sodium tetraborate.

By the first of 1919 the American Trona Corporation will be producing some 40 to 50 tons of refined borax daily analyzing 99.50 per cent  $\text{Na}_2\text{B}_4\text{O}_{10}\text{H}_2\text{O}$ .

#### PUMP HOUSE, TRANSFORMER STATION AND MANIFOLDS

The pumping equipment consists of two all-iron centrifugal pumps each capable of delivering 750,000 gal-

Vergne ice machines, driven by three Corliss engines of 300 hp. each.

#### TRONA REEF, NORTHEAST END OF SEARLES LAKE

The company owns some seven hundred acres of claims here. The high grade trona in these claims amounts roughly to 40,000 tons. Besides this there are some 20,000 tons of a lower grade trona comprised in these claims.

The American Trona Corporation has built a raised road completely across the lake, connecting the Trona



FIG. 6.—GENERAL VIEW OF PLANT

lons of brine per twenty-four hours to the company's storage tanks. The pumps are connected by short manifolds to six wells drilled through the crystal body.

The pump house and a raised road on which is operated a narrow-gage, gasoline locomotive and dump cars, are built directly on the surface of the crystal body, as shown in Figs. 4 and 5. Our assay map of the crystal body has shown us that this is the most favorable location for our pumping plant.

The road built out to the pump house is about three and one-half miles long. Between 19,000 and 20,000 feet of ten-inch iron pipe connects the pumps with two storage tanks of 500,000 gallons capacity each. The pipe line is laid on concrete piers. It is insulated against changes in temperature by a two-inch layer of hair felt and a one-inch layer of wool felt, the insulation being protected against the elements by a thin sheet of black iron, which is fastened by narrow iron straps.

In Fig. 6 is shown a general view of the plant. At the left are the storage tanks. Next is the boiler plant containing 12,500 hp. Babcock & Wilcox boilers, which supply steam for operating the steam turbines; high-pressure water pumps for the Pelton water wheel drives on the pumps; elevators and propeller shafts of the evaporators, and the Corliss engines which drive the ammonia compressors in the new refrigerating unit. The exhaust steam from these turbines and steam engines is fed to the evaporators.

The Pelton water-wheel drives having proved costly and inefficient to operate, the new management is replacing them with electric drives, thus effecting a considerable saving in oil.

Between the boiler houses and evaporator buildings rise concrete chimneys, 15 ft. high and 9 feet in diameter in the clear on top. The two evaporator buildings will house, when completed, two triple-effect 22-foot diameter Manistee vacuum pans, and two double-effect 16-foot diameter pans of the same design. To the right may be seen the crystallizing house, 180 feet wide and 800 feet long.

The equipment in the refrigerating unit which is under construction consists of three 100-ton De La

Railroad with its Trona claims by a narrow gage, gasoline operated railroad.

#### BRINE STORAGE AND EVAPORATION

The storage tanks shown in Fig. 7 contain a combined capacity of one million gallons or 650 tons. From them the brine is pumped to the evaporators shown in Fig. 8.

These pans stand 86 feet high and are 22 feet in diameter. The calandria or steam belt is comprised in the first section above the working floor, which is thirty feet above the ground floor of the building. Reading from left to right, the pans are numbered 3, 2 and 1.

No. 3 is the low-temperature, high-vacuum pan and it is into this pan that the brine after a pre-heating

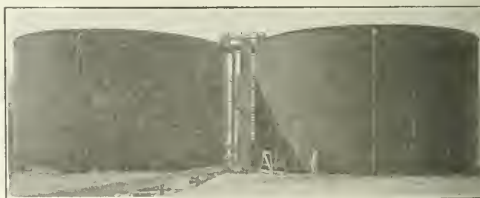


FIG. 7.—BRINE TANKS

in a single-effect 16-foot Manistee pan is pumped, together with a proportionate amount of mother liquor from the sumps in the crystallizing house.

The liquors pass from No. 3 pan through the intermediate No. 2 pan into the high-temperature, low-vacuum No. 1 pan in a steady flow. From No. 1 pan the now concentrated liquors, having a specific gravity of 1.385 to 1.390, are pumped over to the crystallizing house. Exhaust steam from Terry steam turbines is fed to No. 1 vacuum pan from a mixing drum.

To the left of No. 3 pan is shown a rotary jet condenser. This pump, operated by a 500 hp. Terry steam turbine, functions both as a vacuum pump and condenser, handling the vapor from No. 3 pan. The condensed vapors and cooling waters are pumped from the condenser and returned to the spray pond by an auxiliary booster pump. Some 7000 gallons of condensed and



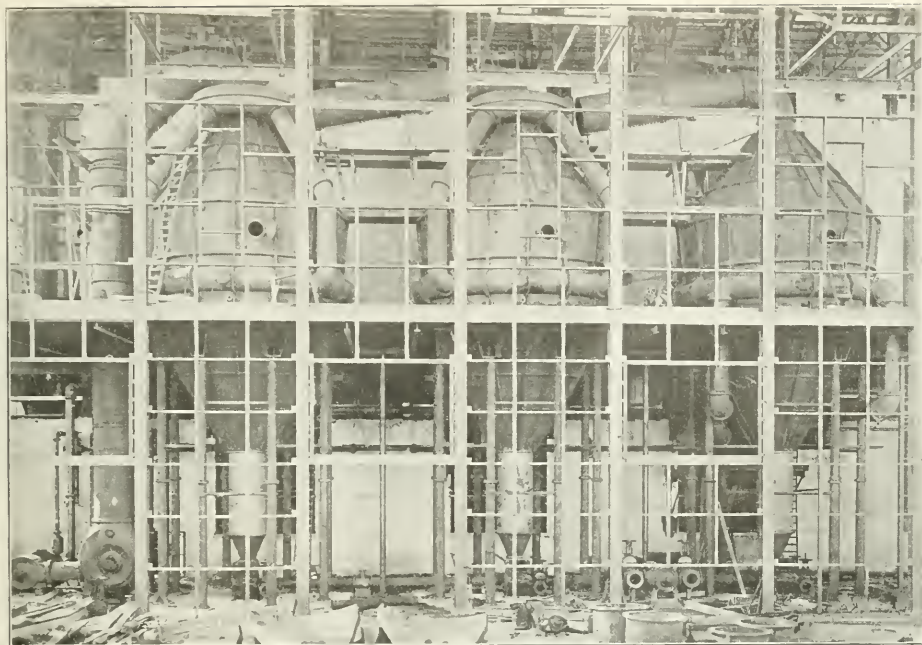


FIG. 8.—BATTERY OF MULTIPLE EFFECT EVAPORATORS

cooling waters are forced through the sprays every minute.

#### UPPER FLUE SHEET OF A 22-FOOT MANISTEE VACUUM PAN

The men shown in the photograph, Fig. 9, are expanding the two-inch diameter, six-foot charcoal-iron flues into the upper flue sheet of the calandria.

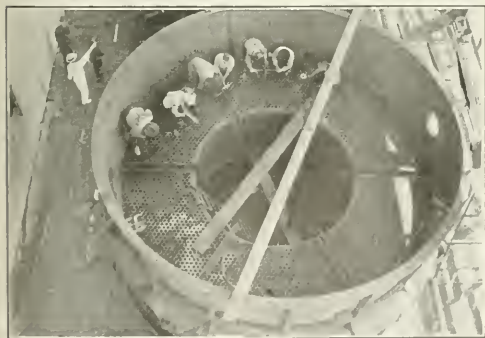
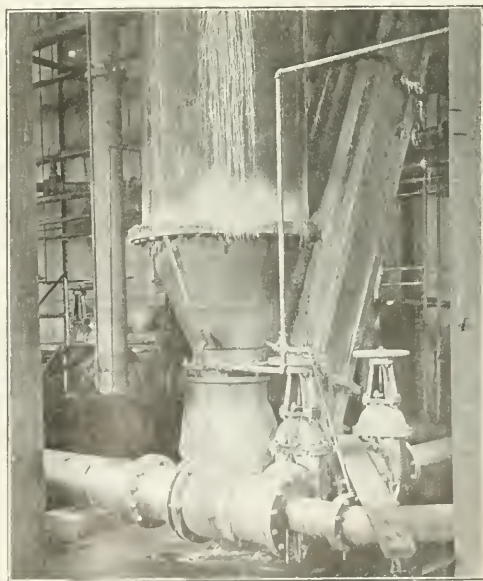


FIG. 9.—UPPER FLUE SHEET OF CALANDRIA

22-foot pan contains about three and one-half miles of such flues.

A propeller shaft, extending through the length of the pan from the top of the pan to well below the calandria, and making thirty revolutions per minute, increases the circulation of the heavy pan liquors through the flues; heavy mineral oil prevents foaming.

In Fig. 10 are shown the evaporator leg pipe and tailings elevator. These tailings-salt elevators handled roughly 350 tons of waste salts per twenty-four hours. These salts are dropped by gravity into waste-salt cones

FIG. 10.—EVAPORATOR LEG PIPE AND TAILINGS  
ELEVATOR

from which they are flushed with brackish water back on to the lake.

In the background of Fig. 11 may be seen the Pelton-Doble water-wheel-driven pump with its set of connections for filling and draining the vacuum pans. It has a

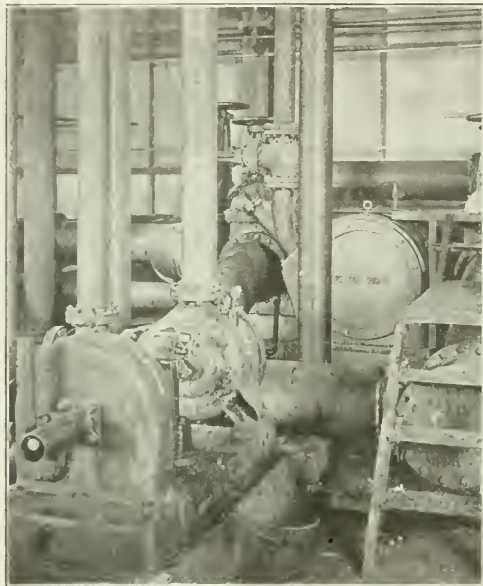


FIG. 11.—PUMPS FOR CHARGING BRINE TO EVAPORATORS

capacity of 6000 gal. per minute. The suction and discharge openings are 16 inches in diameter.

By opening any two of the six valves shown in Fig. 12, the pans may either be filled with raw brine prior to starting a run; drained into large storage vats prior



FIG. 12.—VALVES CONTROLLING THE BRINE LINES

to boiling out (which in the present cycle is done after every run of thirty-six hours); filled with brackish water for boiling out to clean pans; or drained of same after boiling out has been accomplished. The rotary

jet condenser used on the "high vacuum" pan is illustrated in Fig. 13, showing reduction gears and the 500-hp. Terry steam turbine for driving them. The booster pump for removing cooling and condensed waters is in the background.

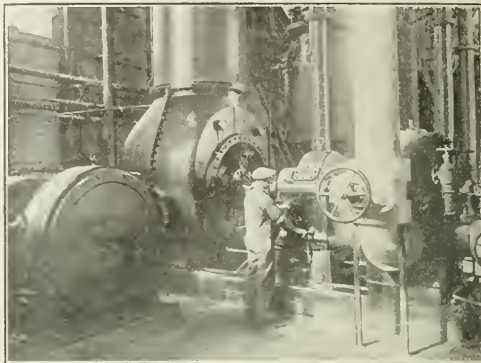


FIG. 13.—ROTARY JET CONDENSER

Fig. 14 shows a triple-effect unit of 22-foot Manistee vacuum pans as they appear when completed. They are insulated with two-inch corrugated air cell asbestos. On top of this is spread a layer of plaster about one inch thick, and on top of this is a covering of 10-oz. duck, the whole being finished off with a coating of white paint.

In the distance may be seen a part of the 16-foot

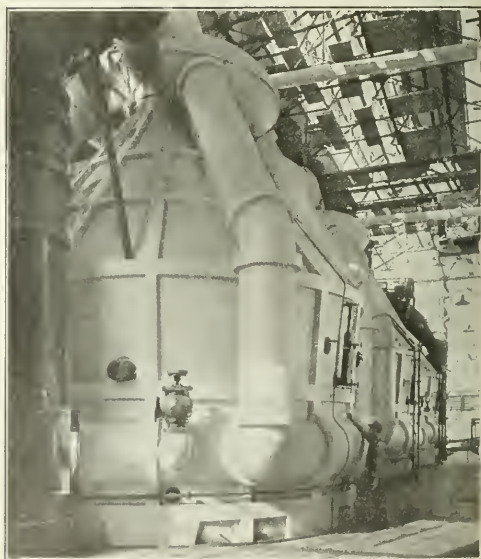


FIG. 14.—VACUUM EVAPORATORS SHOWING INSULATION

single-effect pan now used as a pre-heater for the raw brine fed to the No. 3 pan.

The interior of the crystallizing house is shown in Fig. 15. This picture shows two of four rows of crys-



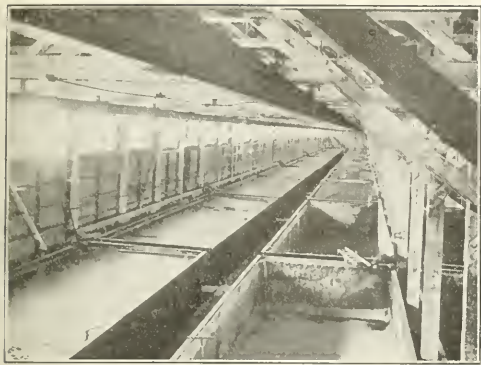


FIG. 15.—VIEW OF CRYSTALLIZING VATS

tallizing vats. These vats are 54 feet long, 15 feet wide and 6 feet deep. They hold 30,000 gallons of concentrated liquor. An average of 15 tons of crude potash salts is taken from each vat. There are 36 such vats in use for the one unit which is now operating.

#### POTASH IN THE CRYSTALLIZING VATS

It takes from seven to eleven days for a vat to cool to near atmospheric temperature, depending on the time of the year. At present, during summer weather at Searles Lake, the vats are dropped at from 40 to 45 deg. C. In the winter when the nights are very cold



FIG. 17.—POTASH STORAGE FLOOR

the temperature of the vats drops more quickly, and the mother liquor is returned to the system at from 25 to 30 deg. C.

All of this has a big effect, not only upon the quantity and nature of the salts produced, but it also has a big effect upon the actual operation of the vacuum pans themselves.

The crude potash salts are carried from the vats to the drain floor in boxes of 2000 pounds capacity, which are operated by self-propelled electric hoists. The potash stays on this drain floor for about seven days before it is passed through a Stedman mill prior to being loaded for shipment.

Trona, Cal.



FIG. 16.—REMOVING POTASH FROM CRYSTALLIZING VAT

#### Zeolites as Potash Collectors

ACCORDING to Dr. F. W. Clarke, in the Data of Geochemistry, U. S. Geological Survey *Bulletin* 491, the average proportion of potassium to sodium in river waters is as one to four, while in sea water the ratio is one to thirty. In igneous rocks sodium and potassium are nearly equal, and in view of the greater solubility of most of the potassium salts it would seem as if the mysterious disappearing process began as soon as the rocks weather. The reason for this, as given by the same authority, is that ordinary soils, and more particularly clays, are able to remove a considerable proportion of potash salts from their solutions and that these are removed from natural waters as they percolate through the soil, or by the suspended silt carried through the streams. The sodium is not so largely withdrawn, so that its relative proportion in solution increases. Thus the metal with more soluble salts is deposited with the sediments while that with less soluble salts remains in solution. Experiments on Hawaiian soils by Crawley and Duncan show that a layer six inches thick will fix over 98 per cent of the potassium in a solution of potassium sulphate which is allowed to filter through it.

This feature of zeolites would point to a method of collecting potassium from river waters were it not for the fact that calcium and magnesium take precedence over alkali metals and that the latter form their substitution products only under mass action.

In analysis of red clay from ocean bottoms made on the Challenger expedition and later confirmed in the laboratory of the U. S. Geological Survey, it was noted that potassium was commonly but not always in excess of sodium. How to get these deposits up a mile or more from the floor of the sea would require the wit of another Herman Frasch, and even then the potash content of less than three per cent is not industrially promising. Glauconite, which is a hydrated silicate of potassium and ferric iron, is widely disseminated upon the sea bottom but most abundantly near the mud line surrounding continental shores. It is also found in the New Jersey green sands and it would hardly seem worth while to go under water for it when it may be found on dry land.



## Extraction of Potash from Kelp\*

BY C. A. HIGGINS

THE recovery of potash from kelp, and the utilization of kelp ashes, principally as a fertilizer, is an art that has long been practiced. Many centuries before the German Syndicate began to market potash salts from their Stassfurt mines, the crofters around the rocky shores of Scotland and the Northern Coast of France had burned the drift kelp as a fuel and scattered the ashes over their land as a fertilizer. The great success which resulted from the use of this kelp ash on the land caused a rapid expansion in the business of kelp harvesting, until about the beginning of the 19th century, quite a flourishing industry had already sprung up.

The opening of the German potash mines, however, about the middle of the nineteenth century, began to flood the market with potash at a price far below that at which the old kelp burners could produce it, and although the kelp-potash industry still struggled along in isolated parts of the coast amongst the Scottish crofters, and to some extent in Japan, it may be said that the German production killed the kelp industry, which had up to that time attained fairly considerable proportions.

The outbreak of the present war, however, drove potash users to look for new sources of supply, and naturally one of the first to come to their attention was kelp. Previous to the outbreak of the war many writers had drawn attention to the huge perennial beds of kelp which grow practically uninterrupted all along our coastal waters on the Pacific side, from the Mexican line to Alaska, and around the scattered groups of islands which lie close to the California shore. These vast fields of kelp seemed to offer inexhaustible supplies of potash, which according to the preliminary survey made by the Government, bade fair to supply far more than the normal requirements of our country for the indispensable muriate of potash. All that remained was to devise economical means for harvesting these vast beds, and drying and reducing the kelp to a suitable condition for transportation and use as a fertilizer. Within a few months, therefore, of the cutting off of the German muriate, various large companies were prospecting the Pacific coast for suitable sites on which to erect plants for the harvesting and extracting of potash from the Pacific kelp.

### OLD AND NEW METHODS OF HARVESTING

The earliest attempts at harvesting were very crude and involved a good deal of manual labor. Men in flat-bottom scows would reap the weed by hand with large sickle knives and burn it in a rather primitive way. The ash was afterward sold to the big fertilizer companies at a price based upon the potash content, which generally ranged around 15 per cent K<sub>2</sub>O. Later, however, modern methods were installed for the harvesting of kelp. Large flat-bottom, steam- or gasoline-propelled scows were equipped with a mechanical reaping device and band conveyors which cut the kelp and conveyed it in one operation into the tanks aboard the harvesting vessel, at very much less expense than that involved in the old method of handcutting. These harvesters, when filled, then proceeded to shore under their

own power and discharged their contents into hoppers at the plant, which in turn fed series of mechanical dryers where the kelp leaves were dried and partly incinerated by passage through revolving drums heated by oil burners. The dried incinerated kelp leaves were then ground and sacked and ready to be shipped to the fertilizer factory. Some attention is paid in the drying process to insure that a minimum of the potash and nitrogen content of the kelp is lost by the destructive distillation effect of the drying equipment. That, briefly, is the method now in use in plants where potash is considered as the only valuable constituent of the kelp. Experience has shown, however, that this process of producing potash and realizing the values of kelp is very expensive, and will exist possibly just so long as the war and the present high price of potash last.

### HIGH COST OF POTASH FROM KELP MUST BE REDUCED BY BY-PRODUCTS

A few figures will show the status of the kelp-ash industry in this regard. Using the modern harvesting methods that I have already briefly touched upon, experience shows that it costs around \$1.10 to harvest and bring a ton of kelp leaves ashore. Analyses show that the average potash content of the raw kelp as harvested in California coastal waters is about 1.3 per cent K<sub>2</sub>O, which means that it costs about \$85 to bring in the green kelp equivalent of 2000 lb. of 100 per cent K<sub>2</sub>O. On top of this, of course, has to be added the costs of drying these kelp leaves, which contain about 90 per cent of moisture, and by reason of their gelatinous and cellular structure, present quite a problem in desiccation. All indications seem to point very clearly to the fact, therefore, that any industry which looks to the production of potash from kelp on a permanent peace-time basis, must reduce its cost very considerably, or produce valuable by-products in the same process which in turn will effect a reduction in the cost of the potash.

Along these lines certain investigators have suggested as far back as a century ago that the peculiar algal bodies present in kelp might be profitably recovered and used in certain directions in place of gelatin, for the sizing of paper and textiles, the proofing of cloth, and in the production of rubber substitutes and admixtures. Another interesting suggestion is that of Prof. T. C. Frye, who made a conserve by first leaching out the potash and soluble salts and afterwards soaking the kelp in cane sugar solution flavored with lemon. In Japan a kind of sour pickle with vinegar is made from the fleshy parts of the kelp. The kelp fibre when compressed and dried also forms a hard substance resembling ebonite or vulcanized fibre, and at least one concern is working along these lines at the present time. The production of by-product iodine from kelp, however, has long been a practical proposition, although hampered somewhat by the competition of by-product iodine from the Chilean nitrate fields.

The biggest practical advance in the economical production of potash from kelp was marked in the year 1915, when the Hercules Powder Co. started the construction of large gasoline-propelled marine kelp harvesters and a factory located near San Diego, California.<sup>1</sup> This equipment was designed primarily for the produc-

\*Report of an illustrated address at the Fourth National Exposition of Chemical Industries, New York, Sept. 25, 1918.

<sup>1</sup>Illustrated article in this journal, June 1, 1918.

tion of acetone, potash and iodine from kelp. Kelp as a source of acetone was something entirely new to chemical industry, and chemists all over the world have watched the growth and development of the undertaking with great interest. The plant since its inception has rapidly increased the number and range of its products, and placed upon the market some new materials which are full of industrial promise.

Reduced to its simplest terms, the basic principle of this process of kelp reduction lies in the destruction of the cellular tissue of the kelp leaf by fermentation, bringing the potash into solution, and producing acetic acid as the product of the fermentation of the kelp leaf. The acetic acid is neutralized with limestone, giving calcium acetate, potash, and iodides in the solution.

The products chart, shown in Fig. 1, will give a general idea of the operations at this plant and serve as an introduction to the more detailed description that follows. With this I think we can outline quite clearly the

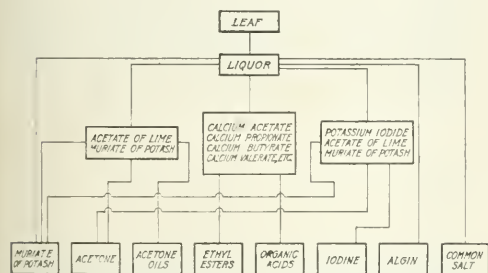


FIG. 1. KELP PRODUCTS CHART

principal steps involved and the products produced in the fermentation of kelp. The kelp is harvested and brought to the plant, pumped from the tank barges into the fermentation vats where it is allowed to ferment until the kelp leaf goes into solution and a liquor is obtained which on evaporation and concentration yields, at various stages, three intermediate salts.

#### SEPARATION OF POTASSIUM CHLORIDE

The first intermediate salt, consisting of a mixture of acetate of lime and muriate of potash, is heated in regular acetone retorts, which produce acetone from the acetate, leaving as residue muriate of potash and calcium carbonate, from which the high-grade muriate is separated by leaching and subsequent crystallization. The fractionation of the crude acetone yields a certain amount of light and heavy acetone oils, in addition to the C. P. acetone.

Intermediate salt No. 2, consisting of the calcium salts of the higher fatty acids, is mixed with alcohol and sulphuric acid and the corresponding ethyl esters produced by well-known methods. These esters are easily separated by fractionation. Ethyl acetate, ethyl propionate and ethyl butyrate in commercial quantities are now on the market from this source and are finding very extensive application as solvents in the soluble-cotton industry, in the manufacture of artificial leather etc.

Intermediate salt No. 3, consisting principally of potassium iodide, is treated with chlorine and the precipitated iodine dried and resublimed.

#### GELATIN SUBSTITUTE, AMMONIA AND MEDICINAL CHEMICAL ALSO RECOVERED

The last of the final products shown on the chart is algin. This substance is at the present time being produced from the residual unfermented leaves which are screened from the liquor coming from the fermentation vats. These leaves are treated with sodium carbonate which extracts the algin in the form of a soluble sodium salt which is afterwards precipitated and purified. So far, but little progress has been made in the commercial development of the use of this algin as an article of commerce. The perfection of extraction manufacturing methods however, and the increasing cost of gelatin and vegetable gums, leads to the conclusion that this material may find a very extensive use in the future.

In addition to the foregoing valuable products, promising experiments are now in hand whereby ammonia, valeric, and caproic acids are being recovered as by-products in the fermentation of kelp. Nitrogen combined as ammonia exists to the extent of about 0.2 per cent in kelp, and is left in the liquor after fermentation of the leaf. Valeric acid as the isoform is much needed at the present time in the treatment of nervous disorders, the supply of the valerian root from which the medicinal valerates were formerly made having been almost entirely cut off.

#### KELP POTASH CANNOT COMPETE WITH UNRESTRICTED EUROPEAN SUPPLIES

Sufficient has been said I think to indicate that the kelp industry from being conceived solely as a source of fertilizer potash will eventually develop along the lines of fine chemicals with high grade muriate somewhat in the position of a by-product. It is doubtful whether the total potash production of all the kelp-harvesting concerns at the present time amounts to more than about 25 tons a day on the basis of 80 per cent muriate of potash. Of this, more than a half is of a high grade of purity about 95 per cent KCl, and is produced not by the original method involving the incineration of the kelp, but by the fermentation process already referred to.

It may be a little early yet to speak definitely of the future of the kelp industry and its future bearing on potash. Certain it is that with kelp-production factories extending all along the Pacific Coast, our domestic demands for potash cannot be met thereby. Certain it is, too, that kelp solely as a source of potash will never compete with unrestricted supplies from Europe or even with that recovered in modern cement or blast-furnace practice. The utilisation of kelp in such a way, however, as to realize on all its other possible values, some of which have been touched upon may help to render the users of high-grade potash for chemical purposes outside of the fertilizer trade, independent of foreign supplies.

#### Soluble Potash from Feldspar

B. F. Halvorsen of Christiania, Norway, patents the process of heating a mixture of finely ground feldspar, cyanamide and alkali salts to 650 deg. C. in the presence of superheated steam, whereby he gets ammonia and a good yield of soluble potash, which is refined by crystallization. (Eng. Pat. 107,012, May 30, 1917.)

## Potash as a By-Product

Southern Iron Ores and Fluxes Considered as a Domestic Source of Potash in Large Quantities—Analysis of Raw Materials—Estimated Cost of Operation—Probable Recovery and Profits

By J. S. GRASTY

Geological and Chemical Engineer, Charlottesville, Va.

IT IS, of course, a matter of general information that prior to the war Germany supplied practically all the potash salts used in the world. With but small reserve supplies of potash and the German supply entirely cut off this country has in consequence faced a serious shortage in this material so essential as a fertilizer. The best indication of this fact is that high-grade potash salts are now quoted at approximately \$350 to \$425 per ton, whereas the normal price before the war was \$35 to \$40 per ton. Further evidence on this point is given in Table I on imports of potash salts:

TABLE I—IMPORTS OF POTASH SALTS

|                       | Pounds      | Value        |
|-----------------------|-------------|--------------|
| 1912                  | 622,179,164 | \$10,692,285 |
| 1913                  | 612,514,916 | 10,805,720   |
| 1914                  | 485,818,459 | 8,743,973    |
| 1915                  | 170,550,450 | 3,765,224    |
| 1916—January to April | 3,091,250   | 379,260      |

These figures show that before the war over 600,000,000 pounds of potash salts were imported annually. Of this quantity approximately 500,000,000 pounds was in the form of chloride and 100,000,000 pounds in the form of sulphate, both of which salts are used especially for fertilizers. In 1915 the imports were less than 200,000,000 pounds, 90 per cent of which was used by the fertilizer industry.

If our normal annual consumption of potash be represented by the figures for 1912, there was in 1915 a shortage of over 450,000,000 pounds, and judging from the figures this shortage was much greater in 1916.

Table II gives the potash production of the United States for 1917:

TABLE II POTASH PRODUCTION, UNITED STATES, 1917

| Sources                                                 | Number of Producers | Available K <sub>2</sub> O, Short Tons |
|---------------------------------------------------------|---------------------|----------------------------------------|
| Mineral Sources                                         |                     |                                        |
| 1. Natural brines                                       | 10                  | 20,652                                 |
| 2. Alunite (refined salts, crude and wasted alunite)    | 3                   | 2,402                                  |
| 3. Dust from cement kilns                               | 3                   | 1,621                                  |
| 4. Dust from blast furnaces                             | 3                   | 185                                    |
| Organic Sources—                                        |                     |                                        |
| 1. Kelp                                                 | 10                  | 3,572                                  |
| 2. Molasses residue from dist                           | 4                   | 2,846                                  |
| 3. Wood ashes                                           | 36                  | 424                                    |
| 4. Evaporated Steffens water from sugar refineries      | 5                   | 359                                    |
| 5. Evaporated wool washings and insol, industrial waste | 3                   | 305                                    |
|                                                         | 82                  | 32,366                                 |

According to the U. S. Geological Survey, the production of potash for the first six months of 1918 was between 20,000 and 25,000 tons of K<sub>2</sub>O, and it is estimated that the total production for the year will reach 60,000 tons. On the other hand, the Bureau of Soils estimates that the cement plants of this country should be able to produce more potash alone than the total estimate for 1918<sup>1</sup>. However, it should be remembered that this is only 25 per cent of our normal requirements.

<sup>1</sup>Commenting on this the editor of the *Manufacturers' Record*, Sept. 22, 1918, calls attention to the fact that the blast furnaces could probably produce 200,000 tons of K<sub>2</sub>O per year, at the same time obtaining a cleaner gas for their stoves and gas engines.

### SERIOUS SHORTAGE OF POTASH

The present condition of potash shortage is so serious that both the U. S. Geological Survey and the Department of Agriculture have directed special attention to the investigation of new sources of supply. Borings, with practically unsuccessful results, have been made in the "Red Beds" of the West and elsewhere in the endeavor to locate suitable deposits, and to determine whether or not potash salts are to be found in association with beds of common salt in sufficient quantity to be of commercial importance, but, as indicated, so far the results have not been satisfactory.

The Bureau of Soils of the Department of Agriculture has been investigating the extraction of potash from the sea weeds (kelps) of the Pacific coast. This Bureau has also investigated the various processes of the extraction of potash from feldspar etc. Important work is also being done by Dr. T. Poole Maynard of Atlanta, Ga., in



TOP BED ON RESER MOUNTAIN

investigating methods of recovery of potash from the sericite schists and slates of Georgia.

The conclusion is definitely reached that a potash industry in order to be successful must be considered strictly from the point of view of cost of production. Many enterprises which are now producing at a profit cannot expect to survive during the post-war period. In fact the only potash industries for which success is assured are those which depend upon recovering potash as a by-product, and therefore this desired end can be attained in the treatment of volatilized products of Portland cement plants and the gases of blast-furnaces by making use of the Cottrell processes of electric precipitation.

Too much emphasis cannot be placed upon the point



that potash produced in this country must be able to compete with that produced in Germany after the war. Potash recovered as a by-product should be produced at a price as low as \$15 per ton after all charges have been deducted. Also the probable tonnage and stability of the industries of which potash is a by-product must



UPPER SEAM AND PART OF LOWER SEAM AT EUMAHEE

be taken into consideration. As previously indicated, there are two extremely important sources of by-product potash in this country, namely, cement plants and iron blast-furnaces. At the present time considerable quantities of potash are being produced as a by-product of cement plants and large profits are being earned.

Very little, however, has as yet been recovered from iron blast-furnaces, although such plants offer a field for the use of processes of recovery as good as, if not better than, cement plants. Nevertheless, sufficient work has been done by Wysor<sup>2</sup> of the Bethlehem Steel Company, Porter of the Security Cement & Lime Company and others to prove that blast furnace gases do contain potash which, in many cases, can be recovered and especially so when employing iron ores which are high in potash.

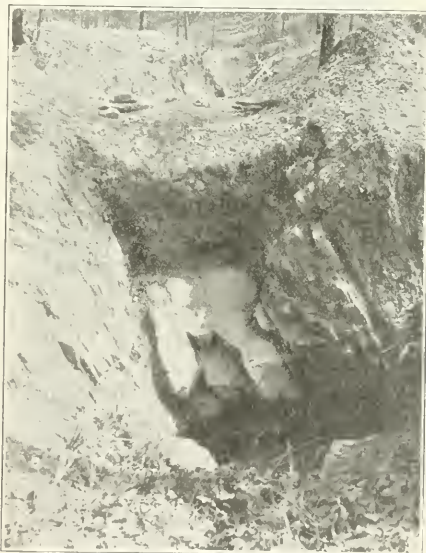
Furthermore, blast-furnace gases should be cleaned of their suspended particles anyway, in order that the efficiency of the furnace may be increased. It has been found that the best way to accomplish this is by use of the Cottrell process, which in addition to cleaning the gases also recovers the potash in marketable condition. Taking into consideration the fact that it is highly advisable from an operating point of view to increase the efficiency of blast-furnaces by employing the Cottrell process to clean the gases regardless of the recovery of potash which is effected at the same time, obviously the potash so recovered is obtained at a practically negligible cost. As a matter of fact, furnace companies could afford to pay well to have their gases cleaned and give the recovered potash to the party doing the cleaning.

#### IRON BLAST-FURNACES AS A SOURCE OF POTASH

Potash recoverable from iron blast-furnaces originates in the iron ore, coke, limestone and other fluxing

agents charged into the furnace; a small amount of potash leaves the furnace in the slag and in the gases. By use of the Cottrell process the gases pass through an electric precipitator before they reach the stoves. With a given slag volume, the amount of potash carried from the furnace in the slag is more or less constant, or rather, it does not exceed a certain quantity. Therefore, of the total amount of potash charged into the furnace, obviously the greater part can be recovered from the gases. On the other hand, it is true that most iron ores, limestones and cokes do not contain much potash; consequently if large results in the matter of potash recovery are to be obtained it follows that one or more of the raw materials employed should be high in this substance.

As to the potash content of fluxing materials, either limestone or dolomite, and of coke there is offered a wide field for investigation; but the information so far available points to the conclusion that the potash content of these is in general more or less constant and fairly low as compared with the variations in potash content to be found in certain of the iron ores. After all, as goes without saying, it is the potash in the iron which is most important, although it is also obvious that



SOUTH SIDE EUMAHEE OPENING

if the fluxing materials and coke be also high in potash that is very desirable too. Furthermore, the presence of potash in the fluxing stone, coke or iron ore has an additional value because of the fact that it acts as a desulphurizer.

#### ONLY LARGE TONNAGES ARE IN ALABAMA

An investigation of the potash content of different iron-ore deposits in the United States as reported by others and as determined by the present writer forces the conclusion that the only large tonnages of potash-bearing iron ores known in this country occur in the State of Alabama. These occurrences are found in the

<sup>2</sup>"Potash as a By-product from the Blast Furnace," by R. J. Wysor, *Transactions of the American Institute of Mining Engineers*, Vol. LVI, p. 257.

eastern part of the State, in Talladega and Shelby counties, and may be assigned on a most conservative basis an aggregate of considerably over one hundred million tons of ore which is much higher in metallic content than the Clinton ores, the latter being the chief reliance of the blast-furnace industry of Alabama.

These relatively high-grade Cambrian ores occur as beds in the Weisner formation of Cambrian age in three districts, the Weewooka, Eumauhee and Columbiana. Metamorphism has altered the Weewooka and Eumauhee ores to a specular or gray hematite, while the Columbiana is bright red. The quality of these ores and their range in composition as compared with other Alabama ores are given in Table III.

TABLE III ALABAMA IRON ORES

|                             | Range in Composition,<br>Per Cent, Fe | Potash,<br>Per Cent |
|-----------------------------|---------------------------------------|---------------------|
| Weewooka and Eumauhee       | 40-52                                 | 1.50-3.00           |
| Columbiana                  | 44-46                                 | 1.00-1.25           |
| Alabama brown ores          | 40-48                                 | 0.20-0.40           |
| Alabama red or Clinton ores | 34-50                                 | 0.15-0.25           |

Ore has been mined and sold from all three of the Cambrian ore occurrences mentioned above, which, by



ORE BED AT EUMAHEE

the way, are controlled by different interests, and has been smelted with most satisfactory results—that is, in all cases where it has been properly mined free from slate. This is a point which seems worth mentioning for the reason that in one instance, at Tallasseechatee creek, the mining was conducted in such a way that the ore shipped was of rather low grade because of careless mining resulting in a large and unnecessary admixture with slate. Most of these Cambrian ore beds are, however, entirely free from slate partings. These deposits are within about forty miles of Birmingham, with other furnaces quite near at hand in the same eastern section of the State.

Referring to Table III, it will be seen that the Cambrian ores, as compared with the Clinton and brown ores of Alabama, are exceedingly high in potash. The value of their high potash content can probably best be emphasized by pointing to the fact that at the Portland



BOTTOM SEAM, NORTH SIDE EUMAHEE

cement plant of the Security Cement & Lime Company at Hagerstown, Maryland, whose deposits the writer located and whose plant has been so successfully managed by Mr. J. J. Porter, the shaley limestone used ranges in K<sub>2</sub>O from 0.75 to 1.10 per cent. The net profits obtained in recovering potash at this plant using the Cottrell electric precipitator amounted during the year 1917 to over \$200,000. Even this large profit, which is enormous considering the required outlay for equipment and operation, will probably be exceeded by a blast-furnace treating a corresponding quantity of material; that is, assuming the blast-furnace runs on these high-potash ores in sufficient quantity and at the same time employs the Cottrell process for catching the potash. It will be seen how closely the comparison holds between a 3000-barrel cement plant, the capacity of the plant at Security, and a 200-ton blast-furnace when it is stated that both handle approximately the same quantity of raw material.

Table IV brings out the potash value to be recovered using Cambrian ores as compared with Clinton ores of different grades:

TABLE IV—VALUE OF RECOVERABLE POTASH FROM CAMBRIAN ORES

| Recovery, per cent. | 40        | 45        | 50        | 55        | 60        |
|---------------------|-----------|-----------|-----------|-----------|-----------|
| Value               | \$467,247 | \$525,643 | \$584,058 | \$642,464 | \$700,870 |
| Recovery, per cent. | 65        | 70        | 75        | 80        |           |
| Value               | \$759,276 | \$817,681 | \$876,087 | \$934,494 |           |

Mr. Charles Catlett of the War Industries Board states<sup>3</sup> that the average analysis of a number of samples of these specular hematites shows a potash content of 2.08 per cent, and he calls attention to the fact that this is over seven times the potash contained in the mixture used by Mr. Wyser at the Bethlehem Steel Company's plant.

Table V showing the cost of producing pig iron, depending upon the kind of ore used, and the estimated results in potash recovery and profits therefrom by the erection of a Cottrell electric precipitator at a 200-ton

<sup>3</sup>Manufacturers' Record, March 29, 1917.



iron blast-furnace, was prepared in collaboration with Mr. Linn Bradley, Chief Engineer of the Research Corporation. In this connection it should be stated that the Research Corporation of New York City owns the patents covering the Cottrell process as applied to the recovery of potash from iron blast-furnaces and for other uses except as applied to Portland cement plants.



WEST SIDE MAIN CUT, TALLASSAHATCHEE

which rights are owned by the Western Precipitation Company. Mr. Bradley having had charge of installations of Cottrell electric precipitators for the Research Corporation since its organization, and having given his attention to the recovery of volatilized products of various sorts by use of these processes, any statement from him on these subjects is authoritative.

TABLE V—ESTIMATED RESULTS OF COTTRELL ELECTRIC PRECIPITATOR INSTALLED AT A 200-TON IRON BLAST-FURNACE

| Items                                                    | Coke      | Limestone | Dolomite  | No. 1 Camb. Ore | No. 2 Red. Ore | No. 3 Brown Ore |
|----------------------------------------------------------|-----------|-----------|-----------|-----------------|----------------|-----------------|
| Material cost, long ton...                               | \$1 00    | \$1 00    | \$5 00    | \$2 00          | \$3 50         |                 |
| Material cost, short ton...                              | \$8 00    |           |           |                 |                |                 |
| Content silica, per cent...                              | 8 70      | 2 00      | 1 25      | 19 20           | 18 00          | 19 50           |
| Content alumina, per cent...                             | 5 00      | 1 00      | 4 80      | 5 00            | 3 80           |                 |
| Lime-magnesia...                                         | 0 30      | 53 00     | 58 88     | 1 30            | 18 00          | 6 10            |
| Potash...                                                | 0 30      | 0 30      | 0 50      | 1 80            | 0 20           | 0 20            |
| Iron...                                                  | 1 70      | 0 00      | 0 00      | 49 80           | 34 00          | 42 00           |
| Ore required for one long ton of iron, pounds            |           |           | 4 398     | 6 365           | 5 212          |                 |
| Percentage of burden...                                  |           |           | 46 07     | 50 93           | 46 87          |                 |
| Coke required for one ton of iron, pounds                | 2 700     |           | 4 480     | 3 000           |                |                 |
| Percentage of burden                                     | 28 29     |           | 35 85     | 26 98           |                |                 |
| Dolomite required for one ton of iron, pounds            |           | 2 448     | 1 652     | 2 909           |                |                 |
| Percentage of burden                                     |           | 25 64     | 13 22     | 26 15           |                |                 |
| Material cost per ton of iron—coke...                    | \$10 80   |           | \$17 92   | \$12 00         |                |                 |
| Material cost per ton of iron—ore                        | 9 82      |           | 5 68      | 8 24            |                |                 |
| (1) Dolomite 90 lb.—limestone 100 lb.—stone              | \$1 09    |           | \$0 74    | \$1 30          |                |                 |
| Total material cost for one ton of iron                  | \$21 71   |           | \$24 34   | \$21 54         |                |                 |
| Furnace capacity in tons iron output per day...          | 230       |           | 180       | 220             |                |                 |
| Total material cost per day                              | \$4 993   |           | \$4 381   | \$4 739         |                |                 |
| Average value per ton iron produced                      | \$33 00   |           | \$31 50   | \$33 00         |                |                 |
| Gross value of output of iron per day                    | \$7,590   |           | \$5,670   | \$7,260         |                |                 |
| Gross profit on iron output per day                      | \$2,597   |           | \$1,289   | \$2,521         |                |                 |
| (Labor, overhead, etc., not considered)                  |           |           |           |                 |                |                 |
| Gross profit on iron output per year, as above           | \$908,950 |           | \$451,150 | \$882,350       |                |                 |
| Total potash content of burden per ton of iron, pounds   | 99 50     |           | 34 43     | 33 97           |                |                 |
| Deduct for losses in slag and elsewhere                  | 20 96     |           | 31 38     | 23 46           |                |                 |
| Potash remaining, unknown portion, collectible, pounds   | 78 54     |           | 3 15      | 10 51           |                |                 |
| Gross value potash at present price \$5 per unit         |           |           |           |                 |                |                 |
| 350 days taken as one year's operation:                  |           |           |           |                 |                |                 |
| Equal to 25 per cent water-soluble                       | \$395,154 |           | \$12,403  | \$50,579        |                |                 |
| Equal to 35 per cent water-soluble                       | \$53,216  |           | 17,364    | 70,811          |                |                 |
| Equal to 40 per cent water-soluble                       | \$32,247  |           | 19,844    | 80,927          |                |                 |
| Estimated net value potash per annum—present 25 per cent | 165,000   |           | 165,000   | 165,000         |                |                 |
| Estimated net value potash per annum—present 35 per cent | 230,154   |           |           |                 |                |                 |
| Estimated water-soluble percentage—35 per cent           | 388,216   |           |           |                 |                |                 |
| Estimated water-soluble percentage—40 per cent           | 467,247   |           |           |                 |                |                 |

It is Mr. Bradley's opinion, backed by data which he has assembled, that a 40 per cent recovery of water-

soluble material may be confidently relied upon as a minimum, though he admits that in practice much larger yields are attained, since, for instance, Mr. Catlett, who has served as chemical advisor of the Security Cement & Lime Company, considers an 85 per cent recovery conservative. Mr. Catlett also estimates that under present conditions potash recovered at a blast-furnace using the Alabama Cambrian iron ores would be worth from \$12 to \$15 per ton of iron produced, which means in potash values alone for a 200-ton furnace \$2400 to \$3000 per day.

As is well known, it is the trade custom to sell potash on a basis of the units of pure potash, a unit being 20 pounds. The present market price for agricultural potash is around \$5 per unit as against 60 and 70c. during the pre-war period. As to this matter of prices, it is the opinion of those best acquainted with the industry that the price of potash will remain relatively high for a number of years after the war.

#### ESTIMATED COSTS AND RECOVERIES

The cost of collecting potash by use of the Cottrell process is estimated in Table VI.

TABLE VI—COST OF COLLECTING POTASH

|                                                                            | Per Unit K <sub>2</sub> O |
|----------------------------------------------------------------------------|---------------------------|
| Collection, including labor, power, repairs and laboratory                 | \$0 14                    |
| Packing and shipping                                                       | 08                        |
| Total operating cost, exclusive of depreciation, royalty and salt addition | \$0 22                    |

The cost of the salt addition—about 25c. per unit of potash—is not a necessary element, and can be omitted



EAST SIDE MAIN CUT, TALLASSAHATCHEE

whenever price conditions are such as to give an unsatisfactory margin of profit.

The following figures<sup>a</sup> taken in connection with the calculated recovery will give a basis for estimating cost in any particular case:

Labor required for operation—1 foreman, who can also supervise packing and loading, and 1 or 2 operators per shift—about \$12 per day.

<sup>a</sup>Manufacturers' Record, March 29, 1917.

All costs given in this paper are recent and are considered correct, but to be conservative from 10 to 15 per cent. might be added to the total.

All figures on operating costs here given have been supplied by Mr. Porter and are based on actual practice at the 3000-bbl. Portland cement plant of the Security Cement & Lime Co. Inasmuch as a 200-ton iron blast-furnace, according to Southern furnace practice, handles approximately the same quantity of raw material as a 3000-bbl. cement plant, the cost of operation of a Cottrell electric precipitator should be approximately the same in both instances.



Laboratory—1 additional chemist,  
say \$4 per day.

Power—1300 kw.-hr. per day for 3000-bbl. plant based  
on dry collection plant—about \$12 per day.

Operating costs and profits would be about as in Table  
VII.

TABLE VII—OPERATING COST

|                                                                   | Per Bbl. Clinker         |                        |
|-------------------------------------------------------------------|--------------------------|------------------------|
| Labor                                                             | \$27 00 per day—\$0 0090 |                        |
| Power                                                             | 25 00 per day— 0083      |                        |
| Repairs                                                           | 8 00 per day— 0027       |                        |
| Laboratory                                                        | 120 00 per mo.— 0014     |                        |
| Salt addition                                                     | 0220                     |                        |
| Total                                                             | \$0.0434                 |                        |
|                                                                   | Present Price            | Assumed Post-War Price |
| Sales price per unit potash                                       | \$4.5000                 | \$1.0000               |
| Value potash collected per bbl. clinker                           | .4675                    | .1039                  |
| Operating cost per bbl. clinker                                   | .0434                    | .0434                  |
| Operating profit per bbl. clinker                                 | \$0.4241                 | \$0.0605               |
| Operating profit per year based on full operation of cement plant | \$458,038                | \$65,340               |

For the benefit of those who wish to estimate the probable recovery of potash at a given plant, the potash content of whose raw materials has been determined by analysis, and the percentage lost in the slag having



ORE BED ON HEGCPACK MOUNTAIN

also been determined, the method of calculation here indicated, which is adapted from that used by Porter for cement, is submitted:

Let *A* equal per cent of potash in furnace burden, i.e., average of  $K_2O$  in ore, stone and coke.

Let *B* equal per cent potash in slag. This ranges from 0.0017 to 0.0065 per cent, average being 0.0039 per cent.

Let *C* equal liberation of potash. This equals:  
9500*A* - 3800*B*

9500*A*

Let *F* equal lb. potash recombined in slag. This compares with potash combined with clinker in manufacturing cement as follows; the range in per cent in cement is from 0.002 to 0.0039, and in slag from 0.0017 to 0.0065, the average in the latter being 0.0039.

Let *P* equal per cent potash precipitated in treaters. This should be 80 to 90 per cent of the total entering. Assume 9500 lb. burden actually used to produce one ton pig iron, and yielding 3800 lb. in slag.

Pounds potash entering furnace per ton pig iron equals 9500*A*.

Pounds water soluble potash entering precipitators per ton pig iron equals 9500*AC* - *F*.

Pounds water soluble potash collected in treaters per ton pig iron produced equals (9500*AC* - *F*) × *P*.

If the average furnace burden be, say, one per cent potash and the loss in the slag 0.0039 per cent., or about

14 lb. per ton of pig iron, then the potash liberation will be about 85 per cent of the total present, and 3.29 units of potash; i.e., 65.43 lb. of potash per ton of pig iron will be produced. The value of a unit of potash is now over \$5, being in fact nearer \$6; but taking it at \$5 per unit, the total value of potash produced at a 200-ton furnace will amount to approximately \$3000 per day. This, however, is assuming that the Cottrell process will effect a recovery such as is experienced in practice, varying from 80 to 90 per cent. But assuming Bradley's minimum of 40 per cent water-soluble recovery, then the total net profit per annum for a precipitator installed at a 200-ton blast furnace—after deducting liberally to cover cost of operation, complete amortization the first year, interest on investment etc., and considering only the positively water-soluble material, i.e. 40 per cent—should be approximately \$500,000, a result which is most amazing, but which reflects the present scarcity of potash as expressed by the prices now obtaining.

#### LARGE PRODUCTION NECESSARY TO PREVENT FUTURE GERMAN MONOPOLY

However, whether maximum profits be attained or not, it should be borne in mind that money so invested would be largely instrumental in giving us complete independence of Germany as a source of potash. Furthermore, no one knows how long the war is going to last, but every one knows that potash is an important plant food. This being the case, and with food and other plant products playing so large a part in winning the war, it is undoubtedly a patriotic duty to push the recovery of potash as a by-product energetically and to the limit. Raw materials high in potash are known, they are well located and available in large quantities; the Cottrell process has been thoroughly worked out, and the recovery of potash by its use, having already passed through the early experimental stages, has been fully demonstrated to yield satisfactory results. It is also highly important to establish the potash industry on a profitable basis in the United States in the near future, so that Germany cannot claim her former monopoly of potash when peace is restored. In view, therefore, of these pertinent facts, those of us who fail to take active steps now in this regard are slackers indeed.

#### The Sylvine Deposit in Alsace

A potassium chloride brine containing very little magnesium, the latter having been leached out during formation, was discovered near Mulhausen in Alsace in 1904, when deep borings were being drilled in testing out this locality for petroleum. In 1909 the first mining shaft was sunk and in the following year, 37,000 tons of potash salts were produced. The industry grew very rapidly and in four years, twelve mines were being operated. The Prussian Potash Syndicate decided to allot to this territory one twenty-fifth of the entire German production of ten million tons, so as to curtail the development of new mines. The extent of the deposit is not definitely established, although about seven square miles of sylvine from six to thirty feet thick, containing one billion cubic yards and one and a half billion tons of crude salts of 22 per cent  $K_2O$  analysis has been located.

# A Wet Process for Extracting Potash from Cement Dust

A Detailed Description of a Humidifying Process for the Precipitation of Potash-Bearing Dust from Cement Kilns, Together with Drawings of a Unique Condenser-Evaporator Set Made of Reinforced Concrete

By J. G. DEAN

Chemical Engineer, Southwestern Portland Cement Co.

ONE TON of potassium sulphate per day is being made at the Victorville, Cal., plant of the Southwestern Portland Cement Co. This is but one feature of a very interesting plant, the details of whose design and operation are largely due to their mechanical engineer, Mr. L. D. Gilbert. The potash plant now operating is hardly more than an experimental installation, and was installed at a cost of approximately \$25,000. However, the modest plant shown in Fig. 1, is rapidly paying for itself, and at the same time is yielding information which is being utilized in the design of a more balanced installation to make a better recovery of water soluble potash on the entire kiln effluent.

## GENERAL FEATURES OF THE CEMENT PLANT

It may be interesting to preface the discussion of the potash recovery system by a brief note on the design of the cement plant, which itself is an example of modern practice, being built in 1915 and 1916, begin-

Chalmers preliminarator followed by a No. 18 F. L. Schmidt tube mill. The latter delivers a slurry containing 35 to 37½ per cent of water, the solids in suspension running 90 to 94 per cent through 200 mesh.

This slurry is then pumped into one of a series of eight round storage tanks, 16 ft. in diameter and 36 ft. high, containing 225 tons of solids—sufficient for 18 hour's burning. After this tank has been filled, it is agitated by compressed air for a period of 2 hours, sampled and analysed for CaO and total loss on ignition. Any adjustment necessary for correct chemical composition is then made by drawing proportional volumes from two or more of these storage tanks, delivering the mixture to a supply tank, which is one of the series shown to the right of the kiln in Fig. 2 exactly similar to the storage tank. When this is filled it is air-agitated, check-analysed, and is then ready for delivery into the kiln.

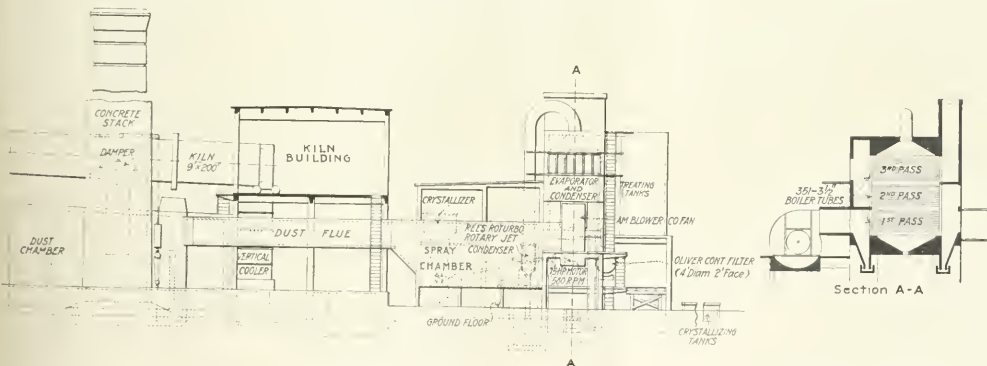


FIG. 1.—EXPERIMENTAL POTASH INSTALLATION

ning operation in September, 1916. The rock, which is a shattered limestone, impregnated with seams of clay, is steam shoveled at the quarry and delivered by standard gage railroad five miles long to the coarse crushing department. Here the rock is broken by a 36 by 60 Allis-Chalmers Fairmont roll crusher, and then delivered to a No. 7 Jumbo Williams mill, which discharges material at about ½-inch size. The discharge from the Fairmont roll crusher may be screened when desired, and the fine screenings washed to remove some clayey material, since the natural product is somewhat deficient in lime. The crushed rock is then elevated to storage bins of 450 tons capacity.

The fine grinding department operates two ten-hour shifts, the rock being wet ground in an 8-ft. Allis-

This kiln, (Fig. 2), is 9 ft. in diameter and 200 ft. long, jointed in the middle, oil burning, and capable of producing 1000 barrels of clinker in 24 hours. The latter is dug from the discharge pile by a clam shell and spread in longitudinal ridges by a locomotive crane running on a track through the middle of a concrete storage-bin, 318 ft. long and 66 ft. wide. The same crane reclaims the material for the finish department by digging across the bin at right angles to the bedding, this method of handling insuring a very well mixed clinker. Grinding is done in an Allis-Chalmers 7-ft. by 22-ft. Compeb mill, from which the cement is discharged and stored awaiting sacking and shipment in a series of bins, 27.5 ft. in diameter and 65 ft. high, each having a capacity of 10,000 barrels.

## KILN DUST

As shown in Fig. 2, the kiln is mounted directly above a concrete dust chamber 12 ft. wide, 14 ft. high and 200 ft. long. Since the wet process was to be used, no great amount of dust was expected, so the chamber was made with a flat bottom and no mechanical device installed to handle the settlement. However, it was found that ap-

use the Cottrell process, and so we cast about for an alternative and hit upon the present scheme.

## PRECIPITATION BY WATER AND WATER VAPOR

Briefly, we planned on spraying the hot gases with sufficient water to wash out the particles in suspension, filtering the spray water from its insoluble sludge, and

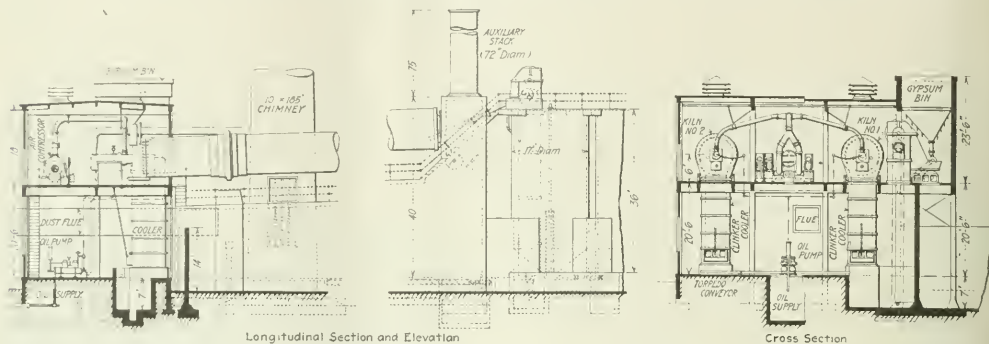


FIG. 2.—GENERAL LAYOUT OF KILN BUILDING

proximately 3 per cent of the solid charged as slurry was recovered in the dust chamber—that is to say, about 270 tons of finest dust had to be shoveled out every month. As shown by the curve, Fig. 3, analysis of this material returned 1.4 per cent water-soluble  $K_2O$  at the kiln end, rising to 2.5 per cent at the stack end. Fig. 3 also shows that the fineness increased progressively, as would be expected; near the stack practically all of the material would pass a 200-mesh screen. The quantity line is approximate, indicating that there is a much greater amount of the low-grade, coarser material than of the finest, higher-potash dust.

While the dust chamber potash was evidently a bird in hand, an economical method of catching the unknown quantities of richest and finest dust emitted from the

evaporating the filtrate. For the latter operation every consideration pointed to the desirability of using the flue gases as a source of heat. Whether to build the evaporator ahead of the spray chamber or beyond it was given careful consideration: in case hot furnace gases above 100 deg. C. were used an evaporator at atmospheric pressure could be utilized, thus simplifying and lightening the evaporator construction and obviating the need of vacuum pump and condensers. However, if these gases were sprayed, they would have required large radiating surfaces or else a prodigious amount of vaporized water would have been lost in the hot saturated stack gases. Furthermore it was early found that the largest excess of water dripping through dusty gases failed to wet and precipitate satisfactory amounts of the solids rich in potassium. This is in line with the well-known difficulty—almost amounting to an impossibility—of satisfactorily and completely wetting finely divided particles such as flowered sulphur and many other condensates. However, if saturated dusty gases are cooled so that the water vapor contained will condense, the nascent globules of mist form about the dust particles as nuclei. Now if the resulting fog can coalesce and be collected in some way the result will be a dust-free gas saturated with vapor at the temperature of escape, and a sludge containing soluble salts in solution and insoluble particles in suspension.

Evidently, then, it was not only necessary to thoroughly humidify the hot gases, but even more necessary to cool the gases to the least possible temperature before their discharge. The radiating heat from these cooling gases could naturally be utilized to evaporate the considerable quantities of weak solutions produced—every pound of water condensed would give up sufficient heat to evaporate another pound of water.

From these and like considerations a condenser-evaporator shown in cross-section in Fig. 1 and discussed in detail later, was placed after the spray chamber. In operation the water which condenses inside the tubes evaporates the same amount outside the tubes; the cool-

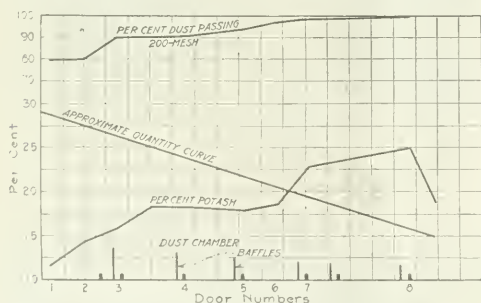


FIG. 3.—RECOVERY OF  $K_2O$  IN DUST CHAMBER

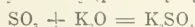
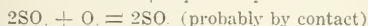
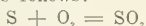
stack urgently demanded attention. A somewhat standardized and familiar solution of this problem is the use of the Cottrell system of electrostatic precipitation. Many of these installations, however, while catching all of the coarser dust, pass a considerable percentage of impalpable material, which unfortunately is most desirable, since it has the largest potassium content of any fraction. Again, owing to certain business considerations we were unable to obtain a satisfactory license to



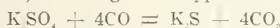
ing furnace gases give up heat to evaporate excess additions, and the gases escape at a low temperature with their waste heat largely abstracted and utilized.

### CHEMISTRY OF PROCESS

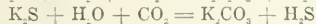
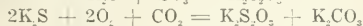
The potassium and sodium in the feldspar and other minerals contained in the cement rock mixture are volatilized as oxides to a certain extent by the intense heat in the clinkering zone, and probably react with sulphuric acid anhydride to form their sulphates. The sulphur in the fuel oxidizes as follows:



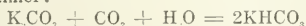
After these reactions take place near the focus, if the sulphates pass on into a reducing atmosphere sulphides will be formed, according to the typical reaction:



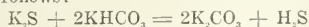
Thiosulphates and carbonates are also formed in the hot, humid gases according to one or more of the following reactions:



On reaching the spray chamber, then, the gases bear particles of fume consisting in part of potassium and sodium sulphides, sulphates, and thiosulphates, together with some complex polysulphides. The water which washes these particles out of the gas also absorbs carbon dioxide. Some bicarbonates will form in the condensate in this manner:



These bicarbonates rapidly oxidize any remaining sulphides as follows:

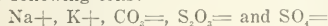


The hydrogen sulphide rapidly hydrolyzes to water and sulphur, which latter reacts with any sulphite, which may rarely be present



A considerable quantity of this sulphur also condenses on the sides of the stack through which the spent, cool kiln gases eventually escape.

Somewhat in the above manner the mixed spray chamber sludge and condensate contains in solution principally the following ions:



Potassium sulphate can readily be separated from sodium thiosulphate; the former crystallizes from hot solutions, while the latter comes down on cooling; therefore it is desirable to remove the  $CO_3^{==}$  and furnish  $SO_3^{==}$  in its stead. This is done at present by drawing the solutions through a bed of gypsum which effects the interchange as follows:



the calcium carbonate remaining behind as an insoluble. Calcium sulphate must be used with circumspection here, however, since gypsum is soluble in thiosulphate, and the whole evaporating system may become overloaded with gypsum, effectually interrupting operations. This may readily be prevented by making sure that a little  $CO_3^{==}$  remains in the solution after gypsum treatment. The test is easily made for the carbonate ion with normal HCl using methyl orange as an indicator. By this titration to a faint pink color the sulphur of the

thiosulphate will not separate out. The solution is then titrated with 0.1 N iodine for the thiosulphation. An increased acidity rarely occurs by the oxidation of the iodine by small amounts of sulphite present.

The liquor now contains  $Na^+$ ,  $K^+$ ,  $SO_3^{==}$ , and  $SO_4^{==}$ . Since there is not enough sulphate anion to unite with all of the potassium present, a part of the potassium would crystallize as thiosulphate if the solution were evaporated. As an actual fact, in the presence of sodium ions the double salt  $K_2S_2O_3 \cdot Na_2S_2O_3 \cdot \frac{1}{2}$  to  $1\frac{1}{2}H_2O$  is formed, which together with  $K_2SO_4$  represents the salt collected from an evaporation in our crystallizing evaporator. Since the amount of sodium present in the weak sodium ions the double salt  $K_2S_2O_3 \cdot Na_2S_2O_3 \cdot \frac{1}{2}$  to  $1\frac{1}{2}H_2O$  vents its concentration. Whenever the  $Na^+$  reaches a saturation point, a small drop in temperature will freeze the crystallizer solid with the sudden precipitation of  $Na_2S_2O_3 \cdot 5H_2O$ . In actual practice the salts as they come from the crystallizer-evaporator are dried and heated to remove a part of the sulphur of the thiosul-

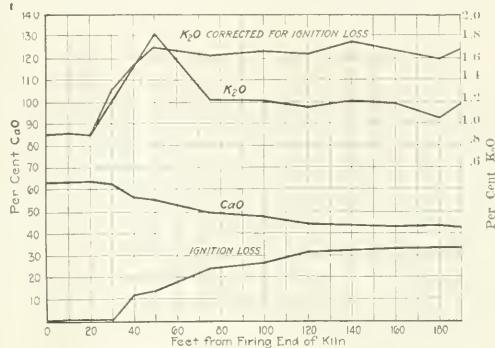


FIG. 4—PROGRESSIVE COMPOSITION CHART OF WET PROCESS KILN

phates. This gives a product of about 90 per cent  $K_2SO_4$ , which is entirely acceptable to our customers.

If it is desirable to prevent the formation of the double thiosulphates, enough  $Na_2SO_4$  may be added to the solutions to furnish the necessary amount of  $SO_4^{==}$  for the  $K^+$  present in excess. This salt also furnishes the requisite amount of  $Na^+$  for the  $SO_3^{==}$ . Pure potassium sulphate will then crystallize from boiling solutions up to the point of saturation of the sodium salt. Now if these hot solutions are drained into a crystallizing tank and allowed to cool,  $Na_2S_2O_3 \cdot 5H_2O$  will crystallize, while the potassium sulphate remaining in the mother liquor can be returned to the primary evaporator.

### BURNING CONDITIONS IN THE KILN

As was stated at the beginning of the discussion of the chemistry of the process, in order to produce the thiosulphates and carbonates in the final liquors it is necessary to have a slightly reducing condition in the kiln. This has been brought about, apparently, by the improper atomization of the oil fuel. While this condition has operated largely in favor of easy manipulation of the potash liquors and the final purification of the potash salts it has not helped in volatilizing the potash from the raw materials in the kiln itself. So far it has

been impossible to volatilize more than about 45 per cent of the potash content, as is shown by the composition chart given in Fig. 4. If the burning conditions could be changed so as to produce the short, intense flame necessary for the most efficient production of cement clinker with the minimum amount of fuel, it

detail in Fig. 5, which is merely a section of the flue about 30 ft. long equipped with fifty Demeral spray nozzles in top and sides. The three tanks in the V-shaped bottom are provided with valves in the bottom, the first of the tanks receiving the condensate from the condenser-evaporator set, as noted later. The collected

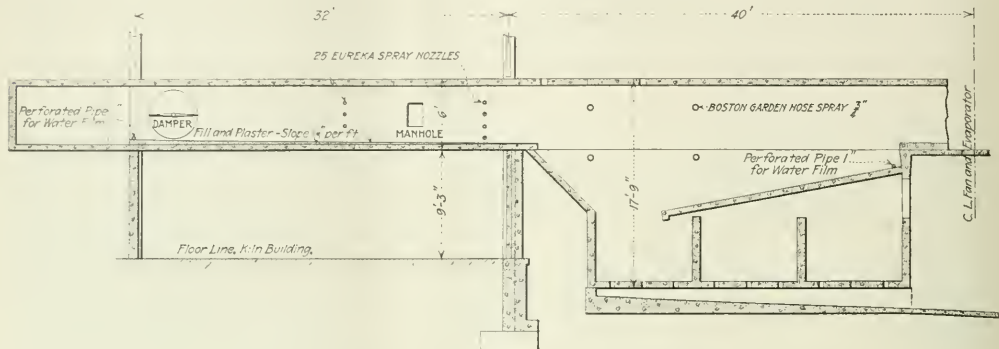


FIG. 5.—LONGITUDINAL SECTION OF SPRAY CHAMBER

would undoubtedly increase the volatilization of the potash considerably at the same time. To do this would destroy the reducing atmosphere necessary for the formation of the thiosulphates and carbonates, and would make the handling of the liquors more difficult and the separation of the potassium and sodium salts practically impossible. However, a method is now under consideration that will make it possible to take advantage of both conditions, giving a maximum cement production and potash volatilization together with our present ease in handling the liquors and purifying the final salts.

The addition of salt ( $\text{NaCl}$ ) to the kiln feed would undoubtedly increase the volatilization of the potash. On the other hand, this would decrease the purity of the final product. The introduction of chlorides is not altogether desirable for other reasons as well. Fluorspar added to the raw material would achieve the same result without the addition of new salts to the final product. In an installation described under "a permanent installation," where all the insoluble dust is returned to the kiln, the  $\text{CaF}_2$  would be reclaimed and used over and over again.

The raw materials as they come from the quarry are somewhat deficient in  $\text{SiO}_2$ . This is corrected by adding a small amount of granitic rock found along the right of way. This material analyzes about 5 per cent  $\text{K}_2\text{O}$ , and its use increases the potash content of the raw materials entering the kiln from about 1 per cent to an average of 1.2 per cent. If we had a pure limestone to use it would be possible to increase the potash content by the addition of the feldspar available to more than 2 per cent.

#### OPERATION OF EXPERIMENTAL PLANT

The drawing, Fig. 1, indicates the main features of the experimental plant. An opening was cut in the end of the dust chamber underneath the kiln and a concrete dust flue built under the firing floor. Just outside the kiln building is located the spray chamber shown in

sludge is drawn at regular intervals into a trough leading to an elevator driven from the fan shaft and from which it is delivered to a small Oliver filter. The filtrate, together with the overflow from the condensate-receivers goes to a concrete storage tank 10 ft. by 10 ft. by 6 ft. deep, holding 4500 gallons.

In passing it may be noted that the atmosphere above the settling tanks as well as the sludge water is strongly charged with ammonia. It is probable that this ammonia comes from the combined nitrogen in the fuel, and its collection is one of the problems for future consideration.

The gases leaving the kiln average 700 deg. F. in temperature. They seldom contain oxygen, and therefore indicate no excess air; in spite of the known reducing condition in the kiln atmosphere they seldom contain carbon monoxide. Table I gives the computation of the kiln-stack conditions, allowing for no infiltration of air, from which it may be computed that at standard conditions of temperature and pressure the gases amount to 15,000 cubic feet per minute and analyze approximately:

|                      | Per Cent |
|----------------------|----------|
| $\text{CO}_2$        | 15.8     |
| $\text{N}_2$         | 46.7     |
| $\text{H}_2\text{O}$ | 36.5     |

On passing through the dust chamber the temperature drops to about 450 deg. F., due to radiation and dilution with the outside air which is drawn through the cracks and expansion joints in the concrete walls. This dilution will average under general conditions approximately 50 per cent.

A considerable excess of water is used in the spray chamber, about 50 gallons per minute being drawn off in addition to that vaporized by the hot gases. These finally enter the condenser-evaporator tubes at 250 deg. F., 79.5 pounds of water having been evaporated to cool the gases to this temperature while passing through the spray chamber.

On entering the tubes of the condenser its volume at standard conditions of temperature and pressure is

24,000 cu.ft. per minute, and its composition may be figured to be:

|                  | Per Cent |
|------------------|----------|
| O <sub>2</sub>   | 6.4      |
| CO <sub>2</sub>  | 9.8      |
| N <sub>2</sub>   | 54.4     |
| H <sub>2</sub> O | 29.3     |

During the passage through the condenser tubes the temperature of the wet gases further falls to 140 deg. F., and is discharged holding only 6.37 pounds of true water vapor per thousand cubic feet of gas, plus some entrapped mist which failed to collect in the condenser tubes. This will amount to between 60 and 75 pounds per minute. The evaporator itself operates at 24 inches vacuum (3 inches absolute pressure at the elevation of Victorville) and a temperature of 115 deg. F.

During the passage through the condenser tubes the gasses have thus radiated the following amounts of heat per minute in cooling from 250 to 140 deg. F.:

|                                                                          | B.t.u.                  | B.t.u.  |
|--------------------------------------------------------------------------|-------------------------|---------|
| O <sub>2</sub> .....                                                     | 1,560 cu.ft. at 2.28 =  | 3,556   |
| N <sub>2</sub> .....                                                     | 13,144 cu.ft. at 2.28 = | 28,968  |
| CO <sub>2</sub> .....                                                    | 2,380 cu.ft. at 2.87 =  | 6,830   |
| H <sub>2</sub> O .359.5 pounds entering at 250 deg. F.<br>contains ..... | 416,021                 |         |
| 114.0 pounds leaving at 140 deg. F.<br>contains .....                    | 127,861                 |         |
| 245.5 pounds condenser losses.....                                       |                         | 288,160 |
| Total radiation in condenser..                                           |                         | 327,514 |

Supposing that 90 per cent of this heat is transferred through the condenser tubes and is utilized in evaporating water at 3 inches absolute and 115 deg. F., 283 pounds of water would be evaporated per minute. (Since one pound of water at 100 deg. F., the temperature of the liquor entering the evaporator, contains 68 B.t.u. and the total heat of water vapor at 115 deg. F., the temperature of evaporation, is 110.2 B.t.u., the difference of 1042.2 B.t.u. is the heat absorbed in evaporating one pound of water. Therefore,  $0.90 \times 327,514 \div 1042.2 = 283$  pounds of water evaporated per minute.)

The water balance for one minute may then be tabulated thus:

|                                                     | Pounds |
|-----------------------------------------------------|--------|
| Vapor from slurry and combustion in cement kiln.... | 280.0  |
| Vapor from spray coolers.....                       | 79.5   |
| Total water entering condensers.....                | 359.5  |
| Less vapor uncondensed.....                         | 114    |
| escaping mist.....                                  | 70     |
|                                                     | 184.0  |
| Balance condensed .....                             | 175.5  |
| Amount evaporated .....                             | 283.0  |
| Excess over condensate.....                         | 107.5  |

This excess is made up by spray-tank sludge, wash water and reagent solutions.

It is apparent that considerable latitude for adjustment is possible in the evaporation system. For instance, if the quantity of weak liquor in the storage tank builds up, it is only necessary to reduce the amount of water entering the spray chamber. This not only produces a smaller amount of sludge water to be evaporated, but passes a hotter gas, which, while it transfers very nearly the same amount of heat through the tubes of the condenser-evaporator in cooling to the proper temperature —140 deg. F.—forms less condensate which must later be evaporated. Or the condensate may be put back

with the spray water, since the water line supplying the spray chamber is connected to the liquor-storage, cooling pond and the regular plant water supply.

#### CONDENSER-EVAPORATOR

As is shown in the drawing, Fig. 6, the condenser-evaporator is of reinforced concrete construction. The flue sheets are  $\frac{3}{4}$  in. steel plates tied to the reinforcing steel at the edges. The concrete walls are heavily reinforced to withstand the outer pressure due to vacuum as well as the inner pressure of the liquor. A few settlement cracks have occurred, but these have been easily sealed by an application of asphaltic paint to the

TABLE I—KILN STACK CONDITIONS AS CALCULATED FROM AVERAGE PERFORMANCE SHEETS

|                                                                                                                                                                                                                                                                 |          |  |           |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------|--|-----------|
| Average conditions employed in calculations:                                                                                                                                                                                                                    |          |  |           |
| Kiln feed = 38 5 per cent water.                                                                                                                                                                                                                                |          |  |           |
| Dried kiln feed = 36 per cent H <sub>2</sub> O, assumed to be CO <sub>2</sub> .                                                                                                                                                                                 |          |  |           |
| 960 lb. of wet feed will, therefore, produce in the process of burning 370 lb. of water, 210 lb. of carbon dioxide, and 380 lb. of clinker, or one barrel. Assume perfect combustion.                                                                           |          |  |           |
| Fuel necessary per barrel = 10 4 gallons crude oil = 84 pounds.                                                                                                                                                                                                 |          |  |           |
| Ultimate analysis of oil:                                                                                                                                                                                                                                       |          |  |           |
|                                                                                                                                                                                                                                                                 | Carbon   |  | Per Cent, |
|                                                                                                                                                                                                                                                                 | Hydrogen |  | 86 06     |
|                                                                                                                                                                                                                                                                 | Sulphur  |  | 11 45     |
|                                                                                                                                                                                                                                                                 | Nitrogen |  | 87        |
|                                                                                                                                                                                                                                                                 | Moisture |  | 1 00      |
|                                                                                                                                                                                                                                                                 |          |  | 50        |
| Amount of oxygen required to burn one pound of this oil:                                                                                                                                                                                                        |          |  |           |
| 0.8606 $\times$ 32 $\div$ 12 = 2.2949 lb. oxygen to burn the carbon.                                                                                                                                                                                            |          |  |           |
| 0.1145 $\times$ 32 $\div$ 4 = .9160 lb. oxygen to burn the sulphur.                                                                                                                                                                                             |          |  |           |
| 0.0087 $\times$ 32 $\div$ 32 = .0087 lb. oxygen to burn the nitrogen.                                                                                                                                                                                           |          |  |           |
| Or it takes 3 2196 lb. oxygen to burn one pound of this oil.                                                                                                                                                                                                    |          |  |           |
| Assuming dry air to contain 23 1 per cent oxygen by weight, then it will require as much air to furnish this amount of oxygen as $3\ 2196 \div 23\ 1 = 13\ 937$ lb. of air. This amount of air will introduce $(13\ 937 - 3\ 2196) = 10\ 7174$ lb. of nitrogen. |          |  |           |
| Then, total air necessary to burn one barrel of clinker = $84 \times 13\ 937 = 1170\ 7$ lb. of air.                                                                                                                                                             |          |  |           |
| Products of Combustion                                                                                                                                                                                                                                          |          |  |           |
| One lb. of oil would produce:                                                                                                                                                                                                                                   |          |  |           |
| 0.8606 lb. of carbon + 2.2949 lb. of oxygen = 3 1555 lb. of carbon dioxide.                                                                                                                                                                                     |          |  |           |
| 0.1145 lb. of Hydrogen + .9160 lb. of oxygen = 1 0305 lb. water.                                                                                                                                                                                                |          |  |           |
| 0.0087 lb. of sulphur + .0087 lb. of oxygen = .0174 lb. sulphur dioxide.                                                                                                                                                                                        |          |  |           |
| Nitrogen in the oil = .0100 lb. nitrogen.                                                                                                                                                                                                                       |          |  |           |
| Nitrogen with the oxygen from air = 10 7174 lb. nitrogen.                                                                                                                                                                                                       |          |  |           |
| Moisture in oil = .0050 lb. water.                                                                                                                                                                                                                              |          |  |           |
| Total products of combustion 14 9348 lb. per pound of oil.                                                                                                                                                                                                      |          |  |           |
| $84 \times 14\ 9348 = 1254$ lb. per barrel of clinker produced.                                                                                                                                                                                                 |          |  |           |
| In burning or producing one barrel of clinker from 960 lb. wet kiln feed and 84 lb. of oil the stack gases would contain:                                                                                                                                       |          |  |           |
| $84 \times 3\ 1555 = 265\ 06$ lb. CO <sub>2</sub> due to combustion.                                                                                                                                                                                            |          |  |           |
| 210 00 lb. CO <sub>2</sub> due to dissociation.                                                                                                                                                                                                                 |          |  |           |
| 84 $\times$ 1 0355 = 86 98 lb. of H <sub>2</sub> O due to combustion.                                                                                                                                                                                           |          |  |           |
| 370 00 lb. of H <sub>2</sub> O due to evaporation.                                                                                                                                                                                                              |          |  |           |
| 456 98 lb.                                                                                                                                                                                                                                                      |          |  |           |
| 84 $\times$ 0 0174 = 1 46 lb. SO <sub>2</sub> due to combustion.                                                                                                                                                                                                |          |  |           |
| 84 $\times$ 10 8174 = 908 66 lb. N <sub>2</sub> with air and oil                                                                                                                                                                                                |          |  |           |
| Total stack gases per barrel of clinker produced, 1,842 16 lb.                                                                                                                                                                                                  |          |  |           |
| Average temperature of stack gases = 460 deg. F. Barometer = 27 2 in.                                                                                                                                                                                           |          |  |           |
| Relative volumes at standard conditions:                                                                                                                                                                                                                        |          |  |           |
| (Without water)                                                                                                                                                                                                                                                 |          |  |           |
| Volume CO <sub>2</sub> = 475 $\times$ 16 $\div$ 1 98 = 15 338 = 15 7 = 25                                                                                                                                                                                       |          |  |           |
| Volume H <sub>2</sub> O = 456 9 $\times$ 16 $\div$ 0 81 = 9 025 = 36 9                                                                                                                                                                                          |          |  |           |
| Volume SO <sub>2</sub> = 1 46 $\times$ 16 $\div$ 2 88 = 8 = 0 0                                                                                                                                                                                                 |          |  |           |
| Volume N <sub>2</sub> = 908 6 $\times$ 16 $\div$ 1 26 = 11,537 = 47 2 = 75                                                                                                                                                                                      |          |  |           |
| Total volume 24,498 99 8 100                                                                                                                                                                                                                                    |          |  |           |
| Volume at 460 d = F and 27 2 in. barometric pressure =                                                                                                                                                                                                          |          |  |           |
| $\frac{458 + 460}{24,498 \times \frac{490}{27.2}} = 50,500$ cu.ft.                                                                                                                                                                                              |          |  |           |
| Density of stack gases compared with dry air =                                                                                                                                                                                                                  |          |  |           |
| $\frac{1,842 \times 16 \div 1.293}{22,793 \text{ cu.ft.}} = 22,793 \div 24,498 = 0.93 = \text{density.}$                                                                                                                                                        |          |  |           |

outside of the walls. A vacuum of 23 to 24 in. at an elevation of 2700 ft. is fairly good evidence that the materials of construction are not lacking in many essentials. The necessary clean-out doors have been placed at each pass, as shown in the detailed drawing. The accumulated sludge is easily removed at intervals of 24 hours with a swab provided with a water spray. Clean-



ing requires about an hour and is easily done, since there are no hard incrustations to remove.

The set contains 1052 tubes,  $3\frac{1}{2}$  in. in diameter and 14 ft. long, divided into three passes, as shown. The only tubes that could be had at the time of building were of very poor quality, which necessitated patching and welding a great many seams. However, we have not experienced the least trouble since placing them in the flue sheets.

In order to provide the extra surface for collecting the condensed water, the tubes are divided into three passes. That portion of the condensate which does not coalesce in the tubes is carried out as entrained mist, as has already been mentioned during the discussion of the water balance of the system. The collected condensate is drained through a water seal to the first

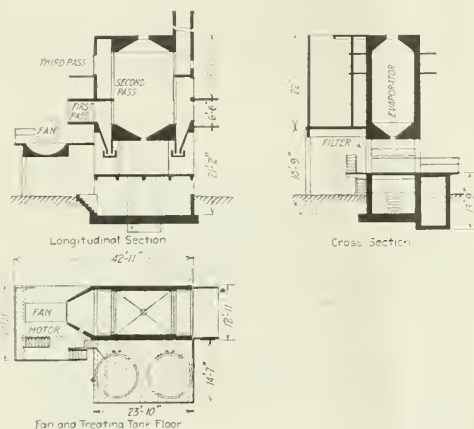


FIG. 6.—DETAILS OF CONDENSER-EVAPORATOR

settling tank provided in the spray chamber (Fig. 5). The combined liquors after passing through the three settling tanks run by gravity to the 4500-gallon tank mentioned in the discussion of the spray chamber, and will average from 2 to 2.5 per cent potassium sulphate.

The liquors surrounding the tubes on the inside of the condenser-evaporator are vaporized by means of the condensation taking place within the tubes. In order to provide the necessary temperature gradient, a vacuum is maintained in the evaporator of from 23 to 24 in. mercury, or an absolute pressure of from 3 to 4 in. Consequently the liquor in the evaporator is vaporized at 115 to 120 deg. F., while condensation on the other side of the tubes is taking place at approximately 208 deg. F. Obviously, the greater vacuum inside the evaporator the greater the temperature drop across the tube, and the lower the temperature of the exit gases.

Vacuum is provided by means of a condenser of the rotating jet type, known as the "Rees-Roturbo" condenser, supplied by the Manistee Iron Works, of Manistee, Mich. This condenser is connected with the evaporator by welded pipe as shown in Fig. 1. The condensing water and condensates flow by gravity to a cooling pond, 50 ft. by 200 ft. by 3.5 ft. deep, where it is cooled by suitable sprays. Cooled water is returned to a well shown directly under the condenser (Fig. 1) and is drawn back to the rotating jets for re-use. The

necessary screens are provided to prevent refuse from entering the machinery.

The Roturbo condenser is direct connected to a 75-hp. induction motor, which also drives the necessary pumps, sludge elevator, and an Oliver continuous filter with its vacuum pump.

The draft fan is belt-driven by a 30-hp. induction motor. The stack between the kilns is provided with a water-sealed damper, while the flue leading to the fan is provided with a swinging damper. Whenever, it is desired to close down the potash treater, the damper in the stack is raised and that in the flue closed so that the operation of the kiln is not interrupted.

#### SAND FILTER AND GYPSUM TREATER

Condensate and spray chamber overflow collected in the 4500-gallon tank contains mud and unconsumed carbon in suspension besides the substances mentioned and discussed under "The Chemistry of the Process." The solids are removed by a sand filter placed in the bottom of one of the gypsum bins at the end of the clinker storage. Whenever the liquors need a treatment for the removal of the  $\text{CO}_3^{=}$  and the addition of the  $\text{SO}_4^{=}$  ions, crushed gypsum rock is spread over this sand filter and the sludge and precipitated calcium carbonate are removed simultaneously.

A filtered liquor is now ready for the condenser-evaporator and is run by gravity to one of the crystallizing tanks shown at the right of Fig. 1. These tanks are 15 ft. by 50 ft. by 4 ft. deep, and hold 25,000 gallons. They were originally built for crystallizing the salts by cooling the saturated brines, but since installing the crystallizing evaporator shown in outline in Fig. 1, and described later, these tanks are being used for storage purposes. As necessary, the weak liquor is pumped into the cylindrical tanks alongside the condenser-evaporator (Fig. 6) and from there flows into the evaporator as needed.

#### KILN DUST CHAMBER

Fine material accumulating in the dust chamber beneath the kiln is at present drawn out through side doors and conveyed to a mixing chamber near the slurry tanks at the upper end of the kiln. This dust is made into a thin slurry with water, and when thoroughly agitated is elevated to an Oliver filter. The filtrate averages about 2 per cent potassium sulphate, and is pumped to the sand filter.

The original intention was to return the filter cake to the slurry tanks, but for some reason not yet determined a very little of this cake will thicken a whole tank of slurry so that it will not run through the outlet pipes provided at the bottom of the tanks. Even if the cake is put into the bottom boot of the elevator, the slurry in the buckets will become so thick and pasty that it will not drop out at the top. However, if the cake is directly introduced into the kiln at about the same rate as it is collected it gives very little trouble, while if too much is fed into the kiln it becomes very dusty and hard to regulate.

A crystallizing evaporator was an after consideration. Originally the liquors were concentrated in the evaporator-condenser to 24 to 26 deg. Bé. and then drained into the crystallizing tanks to cool and crystallize. After

a certain number of days the mother liquor was returned to the evaporator.

This method was too slow and cumbersome. The salts were very wet, the drying was tedious, and as the alkalinity increased in the liquor the amount of solids

drop out of solution they settle into the lower or crystallizing compartment. Every 24 hours the gate valve separating the two is closed and the liquor pumped from the lower to the upper compartment. After the salts are thoroughly drained the door is

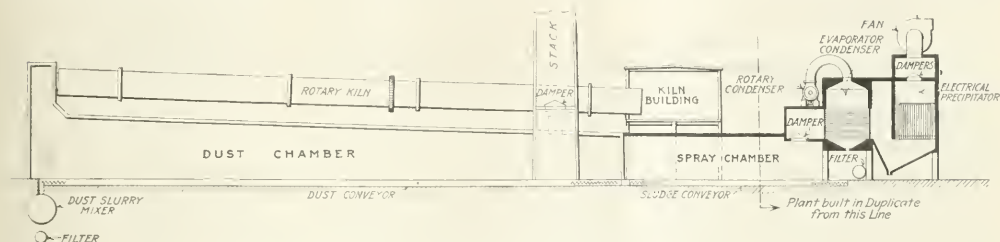


FIG. 7.—DIAGRAMMATIC LAYOUT, COMBINED INSTALLATION, POTASH RECOVERY PLANT

held in solution increased very rapidly. Thus the difference of solubility in cold and hot solutions became so small that we abandoned this method and installed a crystallizing evaporator.

The plan of using the crystallizing evaporator as a second effect to the condenser evaporator was considered. The hot gases in the dust chamber were also a possible source of heat, but it was finally decided to use steam from the boiler in the kiln-room. Of course this is not an economical way of performing the operation, but it was considered best at the time.

The evaporator was designed by Mr. Gilbert, and built at one of the sheet metal shops in Los Angeles. There is nothing about it of unusual design, it being simply a steel tank with a conical bottom closed by a

opened, the salts removed, dried and are then ready for shipment.

#### PERMANENT INSTALLATION

Since the experimental installation is something of a pioneer in this method of potash recovery, it would be nothing strange if some troubles had developed that had not been fully anticipated. These different situations have been met as they occurred, and by their actual or evident solution a design of a permanent plant has been evolved. Fig. 7 is a diagrammatic drawing showing most of the essential changes that would be incorporated.

The dust chamber would be designed so as to be easily cleaned by means of screw conveyors running underneath. It should be mentioned here that there is no particular necessity of having a dust chamber as large as the one here shown. The chamber at present under the kiln was constructed at the time of building the cement plant, while of course the spray chamber was added later. With a shorter dust chamber it would be possible to do all the leaching and filtering at the potash recovery plant and to return the combined filter cake to the kiln.

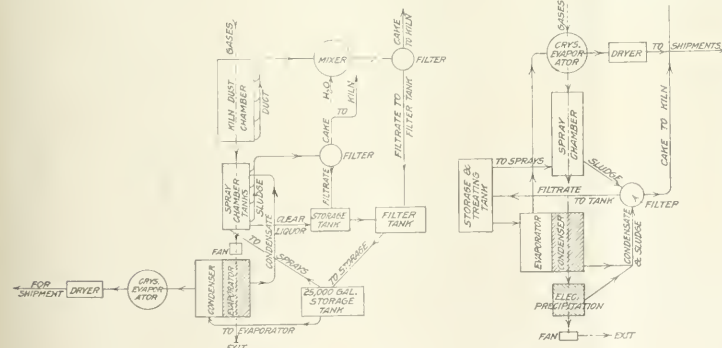


CHART I.—FLOW SHEETS OF PRESENT AND PROPOSED PERMANENT INSTALLATIONS

10-in. gate valve which in turn is bolted to a closed tank beneath, as shown in outline in Fig. 1. This lower chamber is provided with a clean-out door, grate and drain-pipe. The steam basket is built of sheet metal, with ten 3-in. vertical flues. The basket is placed in the upper part of the conical portion of the upper tank with the necessary steam pipe and drain leading through the sides of the evaporator, and the condensed water is returned to the boiler through a trap.

At present the liquors are concentrated in the condenser-evaporator to from 15 to 18 deg. Bé. and then pumped into the crystallizing evaporator. As the salts

for considerable expansion of the gases and for deposition of the dust consequent to a low velocity. The spray nozzles should be capable of giving the finest droplets possible. To avoid hand-cleaning in the spray chamber, it would be advisable to remove the sludge with a screw conveyor direct to the filter. If possible, all liquors should be filtered before being allowed to enter a pump since the incrustation and plugging of pumps has been a cause of many delays and shut downs.

A fan should be placed at the final outlet for the gases. The gases should then be free from all dust, cool and small in volume.

The condenser-evaporator unit would have but one pass. It would be built in duplicate by being divided by a center partition wall with the necessary dampers to permit one side being cleaned while the other side remained in operation. This would make continuous operation possible.

#### ELECTRICAL PRECIPITATION

As was mentioned under the discussion of the experimental plant, the three passes of condensing tubes are used for condensing the vapor and coalescing the precipitated mists so as to remove the water with its dissolved potash from the system. Also it was stated that possibly 60 to 75 pounds of precipitated mist per minute are carried out as an entrainment loss.

In the experimental work on these exit gases it was found that the potash salt carried in solution in the water was not all that was leaving the treater, but at times there were large amounts of potash fume escaping that had apparently resisted the wetting process. This was a great disappointment as it was supposed that if enough water were present during the process of condensation, every particle of dust and potash fume would act as nuclei, and in order to collect all the potash it was only necessary to provide means for collecting all the condensed water particles. If this were the case the small amount carried out by entrainment would not be serious; that is, it would be possible to reduce the loss to possibly 10 per cent, thus giving a 90 per cent recovery.

There are numerous ways of collecting the residual mist, such as condensers, gas scrubbers, coke towers, excelsior beds etc., but the discovery that considerable potash fume had resisted the process of wetting necessitated a different procedure altogether. The application of electrical precipitation to these gases was suggested through the experience of Mr. P. S. Taylor<sup>1</sup> at Riverside, where he was closely connected with the development of the Cottrell electrical precipitation process for the precipitation of the dry dust.

The matter was accordingly taken up with the Western Precipitation Co. of Los Angeles, and they very kindly loaned the necessary equipment and helped conduct a series of experiments on the electrical precipitation of the exit gases.

Without going into a lengthy discussion of these experiments, it may briefly be stated that it was found possible to remove practically all the potash fume contained in the gases, and that at times the water collected in the precipitation tubes carried very little more potash than the regular condensates of the condenser-evaporator, while at other times this precipitated liquor would carry eight to ten times as much potash. This showed that the potash fume in the one case had been efficiently wetted and removed by the process of condensation, while in the other case the potash fume had apparently resisted wetting.

It has been suggested that possibly the reducing condition of the kiln or the presence of the unconsumed fuel might be the cause of this condition. Undoubtedly it is a surface phenomenon, and unfortunately it has persisted in spite of the efforts made to correct it. Whether the presence of dry fume in considerable per-

centages is or is not the usual condition is a matter for further investigation. It seems doubtful, however, that it can be entirely eliminated. In any case, the use of the Cottrell process for the final scrubbing eliminates the possibility of the escape of this fume, and does away with the necessity of the numerous passes necessary with the present condenser-evaporator system to collect a large part of the already condensed mist.

The cool, saturated, foggy gases passing through the precipitation tubes seem to give the ideal conditions for complete electrical precipitation, the voltage necessary being comparatively low and the rate of flow of the gases relatively high. This calls for the minimum number of pipes, electrical connections and other accessories. By having the fan at the exit, the insulation of the electrical connections is greatly simplified.

In the permanent installation these electrical precipitation tubes would be made of cement tile, since their surface would be constantly wetted and conducting. Thus the whole installation would be of concrete construction with the exception of the condenser-evaporator tubes and flue sheets. This is an important consideration at this particular time.

#### HANDLING OF LIQUORS

The crystallizing evaporator would probably be placed in the dust flue in front of the spray chamber. The steam from the evaporator could be returned to the flue so that practically all of the heat would be conserved.

Instead of using gypsum for removing the  $\text{CO}_2$  and increasing the  $\text{SO}_4$  in the filtered liquor, it would be possible to substitute strontium sulphate or celestite. The precipitated strontium carbonate could be dissolved in nitric acid, the solution concentrated and the anhydrous strontium nitrate precipitated from the boiling liquor.

As will be seen from the diagrammatic sketch, Fig. 7, this combination process is very simple and every provision has been made for continuous operation. The coarser particles of dust will be deposited in the spray chamber and removed directly to the filter by a conveyor. Finer dust will lodge in the condenser tubes, and that portion which is not washed out by the condensates can be easily removed by shutting down but one-half of the plant. The cool gases going to the electrical precipitator are thoroughly saturated with water vapor and will carry in suspension a large amount of condensed water in the form of mist. This mist will be precipitated on the sides of the tubes and form a water film for the collection of the dry fumes which will also be caught. The gases passing through the tubes being already saturated and in the course of cooling are unable to absorb more water vapor, so there is no possibility of losing the water film by evaporation. Since there can be no concentration without evaporation, there can be no incrustation of salt in the tubes.

It will be noted in going over the amounts of water collected and ejected from the treater that the maximum amount of potash salts in the final liquor is very small—not exceeding 2.5 to 3 per cent  $\text{K}_2\text{SO}_4$ . This of course necessitates a cheap method of evaporation, which is provided by the condenser-evaporator.

The precipitated liquors from the condenser and the electrical treater, carrying the soluble salts in solution and the fine dust in suspension, will be drained through

<sup>1</sup>"Electrical Precipitation of Cement Dust," *Journal of Electricity, Power and Gas*, Vol. 32, pp. 219-223, March, 1914.



a water seal to the same filter as is used for filtering the sludge from the spray chamber. This simplifies the pumping and piping arrangements and brings together all of the insoluble portion of the collected sludge into one filter cake which can be returned to the kiln. The recombined potash and trapped solution will be contained in this cake, both of which will be quite easily volatilized in the kiln. Of course the insoluble potash would not volatilize so easily, but whatever the treatment necessary for the insoluble potash contained in the sludge, the filter cake presents a convenient form for further treatment.

#### CONCLUSION AND ACKNOWLEDGMENTS

Thus, from the experience gained in operating the present experimental plant there has been evolved a simple and comparatively inexpensive installation for the complete recovery of the soluble potash salts and dust from the kiln stack gases. The weak liquors will be evaporated and the potash recovered in a purified form and the dust returned to the kiln. The operating cost, according to the present installation, would be nearly covered by the value of the returned dust, making the present actual cost of collecting the potash a very small item. In the future even this will undoubtedly be more than offset by the better operating conditions of the whole plant, as the conditions necessary for maximum potash production call for the maximum cement production and the minimum operating expense.

In closing this long, though somewhat incomplete, discussion of this system of potash recovery, it should be mentioned that the work of designing, constructing and operating the plant, as well as the experimentation, has been carried on largely by the combined efforts of L. D. Gilbert, P. S. Taylor, L. E. Elder, and the writer. Mr. C. Leonardt, the president of the Southwestern Portland Cement Co., has been more than generous in providing the necessary funds, and it is largely his great interest and enthusiasm that has made possible the recovery plant and the experience above recorded.

Victorville, Cal.

## The Brown Process for Cement and Potash

WE HAVE received from Mr. Chester Huntington a paper on the process for making cement and potash from feldspar and limestone invented by Mr. H. E. Brown and covered under U. S. patents Nos. 1,123,841, 1,123,864 and 1,124,238. Owing to lack of space we can give but an abstract of the original article and the improvements claimed for it.

Feldspar and limestone are broken in a jaw crusher, mixed, and fed with coke or hard coal into a blast furnace and fused. The potash passes off with the furnace gases and is carried to a dust-collecting apparatus where most of the potash is precipitated in the form of carbonate, oxide and some sulphate.

The molten mass is tapped and run upon a granulating and cooling device where it is sprayed with a solution of magnesium sulphate. The granulated material is dried by the heat of the clinker and is carried to the bins of the cement grinding apparatus.

It is claimed that the cement so produced is of a superior quality due to the excess of silica in colloidal form and to the thorough fusion which eliminates free

lime. This avoids continued chemical action after the cement is set and renders it especially adapted to the construction of sea walls, docks and concrete ships. It may be made free from iron. Tensile strength tests show a higher average than Portland cement. Over 75 per cent of the total potash content may be recovered from the gases. That is, the inventor claims to liberate over 85 per cent of the potash in the change and that a precipitation of 90 per cent may be expected in the recovery apparatus. In experimental practice so far with high-potash feldspar a dust containing over 55 per cent potash was found in the collector.

A further claim is that the cost of a complete potash and cement installation will not exceed 70 per cent of the cost of a cement plant of the same capacity owing to the elimination of preliminary grinding of rock and coal and the consequent reduction of power requirements. The blast furnace should cost less than rotary kilns and take up less room. The housing requirements including the dust collector should not exceed those of a cement mill built on current lines. The grinding of the clinker is by standard methods.

The operating costs should be less than those of a Portland mill, owing to the avoidance of preliminary grinding and because gases from the top of a closed blast furnace may be more economically utilized than the gases from rotary kilns. It is held to be within the possibilities that a well designed plant can be made to supply all its power requirements from waste gases. In short it is claimed that by this process a superior cement is produced at a lower capital outlay and at a less cost per barrel than Portland cement, even if all dust-collecting costs are charged against the cement, and that it makes a vast quantity of potash available as a by-product. In plants that are favorably located it is held that 15 to 18 lb. of potash may be produced to each barrel of cement.

## Literature of the Potash Industry 1912-1917

By F. W. BRUCKMILLER

THE following general review of the potash literature is an attempt to collect in concentrated form the essential statements of the more important articles published from 1912 to 1917. No attempt is made to make an exhaustive report, but it is believed that the articles generally available have been listed. The statements under each reference are just as the writer made them:

#### GENERAL

Cameron (1) points out that as a conservation scheme kelp is of more importance than saw mill or sugar house wastes. The conservative estimated production is 1,000,000 tons of KCl per year from kelp; 5200 tons  $K_2O$  from sawdust; no figures available on sugar wastes. Silicate rocks and brines are not factors in the industry as yet.

McDowell (4) contends that if an American industry is to be built up, "someone must spend money," and two industries that can well afford to do so are the cement and sugar industries. Before brine development can proceed there must be a positive control of acreage.

Cresswell (5) reviews briefly the processes from all sources but gives no data. Numerous references as well as abstracts of articles on working feldspars and silicate rocks are included in the paper.

Dolbear (6) summarizes the efforts in the United States under four heads: (1) From Searles Lake; (2) from "vinasse"; (3) from kelp; (4) from silica rocks. Searles Lake presents a serious unsolved problem of the separation of KCl from a large number of other salts. The Pacific Chemical Co. is constructing a plant for the utilization of "vinasse" from sugar industry. The Kelp Products Co. is operating an experimental plant, with no output as yet.

"Other than wood ashes and vegetable refuse (7) there are four potential sources of potash in the United States; subterranean brines and salt lakes in the West, kelp, feldspar, and known deposits of the alunite type." "Assuming a satisfactory solution of the technical problems, there still remain certain economic problems to be considered, which make it doubtful if kelp will develop into a source of a large amount of potassium salts. The concentration of potash in the brines is so low in comparison to other salts that it is doubtful whether the extraction will ever be commercially possible." "There are no technical difficulties involved in the production of potassium sulphate, impure alumina, and sulphuric acid from alunite." There is no ready market for the sulphuric acid or the alumina. Feldspar investigation still goes on with no production. An industry can be established if there were a guarantee of no price cutting on the part of the Germans.

De Beers (8) groups our sources of potash under by-product and main product plants. Under the former is included wood ashes, bittern, wool, sugar, cement, blast-furnace, and under the latter, kelp, alunite, lakes, and feldspar. Production is now realized from wood ashes, bittern, notably Nebraska lakes, wool, cement, blast-furnace, alunite and kelp. Kelp cannot become a permanent source because of high cost of production. Searles Lake will be an increasing factor in the industry. No productive process for feldspar has yet been produced.

Ebaugh (9) by means of charts and tables shows conclusively the emergency resulting from the embargo on German potash. All efforts so far have been of the "war baby" type. Real success of a potash industry lies in the successful utilization of natural wells, such as feldspar, leucite and alunite.

In an editorial (10) on the potash industry it is pointed out that although natural brines, especially Nebraska lakes, are quite productive, it is doubtful if development will survive a return to normal conditions. Searles Lake presents a real factor in the industry, while kelp, after the war, will not prove a profitable field in spite of over \$4,000,000 investment, unless the Government Experimental Plant brings in positive results. Potash from rocks is difficult to extract, but it is not possible that that problem will forever remain unsolved.

Meade (11) groups the present methods used for getting potash in the United States under four general heads: (1) Evaporation of brines; (2) kelp and ashes of plants; (3) byproduct from cement, iron, beet sugar, and molasses; (4) decomposition of silicate rocks, especially alunite, glauconite and feldspar. The Nebraska

lakes which would promise most under normal conditions and which are reported at the present time to be making a large amount of money, are quite limited as to brine supply, and unquestionably they could only furnish a small part of the potash which has been shipped from Germany. The development of Searles & Owens Lakes depends on a market for soda ash and salt cake. The possibilities of the production of potash salts from kelp on a large scale do not seem to be particularly bright as a post-war proposition. The possibilities for developing an industry in connection with cement and blast-furnaces is excellent. In the processes proposed for the utilization of silicate rocks the quantity of potash produced compared with the by-product is negligible, and under normal conditions its value is generally less, so that with most of them potash is really the by-product and the other constituent the main one. Proper legislation is necessary to protect the industry from the foreign producer.

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According to Maizeres (23), the production of the German syndicate in 1911 was 9,399,269 metric tons of salt.

Maizeres (24) and MacDowell (25) give figures on production by German syndicate in 1912. Total salts mined, 11,164,000 tons salt, representing 1,100,000 tons  $K_2O$ .

The production in 1913 (26) was 13,000,000 tons of crude salt, or 1,413,833 tons  $K_2O$ .

Reference (27) gives the world's production in 1914, while (28) gives a summary of the statistics for imports into the United States during the month of May and five months ending May, 1914 and 1915.

MacDowell (4) gives German production for 1912 at 11,164,000 tons of salts; Cresswell (5) for 1911, 9,706,507 tons, Ebaugh (9) for 1913, 1,721,079 metric tons of  $K_2O$ .

Salcedo (29) discusses the potash production in Chili.

Commerce Reports (30) (31) for 1915 contain information on the developed deposits in Spain.

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## The Kelp-Potash Plant of the Lorned Manufacturing Company

An interview with

LESLIE H. THOMPSON, VICE-PRESIDENT

**K**ELP is a marine plant of high potash content. There are several varieties of potash-bearing kelp, but the only one that concerns the potash producers of Southern California is *Macrocystis Pyrifera*. *Macrocystis* occurs rather abundantly off the mainland and surrounding the coastal islands from Point Conception above Santa Barbara to below the Mexican border. It is attached to the bottom of the ocean by a root-like anchorage called a "hold-fast," and its stems or stripes are sometimes as much as 150 feet long. At the base of the leaf where it grows out of the stem is a pneumaticist, or bulb of air, which holds the strand of kelp on the surface of the water. The rate of growth and the growing period or seasonal growth are still mooted questions. While it is believed that kelp grows all the time, it appears that there are periods when the growth is more luxuriant than others. Our observation leads us to believe that there are two main growing periods about six months apart. The larger and better growth of the two is from July to September, the other from January to April. As a general thing two crops a year, and under some conditions three crops a year, may be harvested.

General control of the kelp beds is vested in the California Fish and Game Commission, which has surveyed,

*Macrocystis* up the coast from the Mexican boundary to Laguna, and include the islands of San Clemente, Santa Barbara and San Nicolas. The manufacturers at Long Beach harvest up the coast from Long Beach to Rincon Point. The manufacturers at Summerland harvest from Carpinteria to Naples. The territory west of Naples and the Santa Barbara Channel islands of San Miguel, Santa Rosa, Santa Cruz and Anacapa, are considered open territory.

### THE PROBLEM OF HARVESTING

The first and most unique problem before the seekers of potash from kelp was that of effectively harvesting the weed itself. It should be understood that the plant contains approximately 90 per cent water, which means that a tremendous bulk of the raw kelp must be handled before a modest amount of potash can be secured. While the methods of harvesting in use by the various manufacturers are similar in principle, there is some variance in the details. Fig. 1 shows a view of the Lorned harvester "Albion," which is equipped with two 60-hp. engines. It has a capacity of 130 tons of wet kelp on deck. The cutting apparatus consists of a horizontal cutter bar equipped with oscillating knives similar to an ordinary mower. At the end of this horizontal cutter bar, which is 12 feet long, are two vertical cutter bars 4 feet long, equipped with the same kind of knives. The cutter is lowered into the water so that the horizontal cutter bar is approximately 4 feet below the surface, and as the kelp is cut it is carried up and deposited on the deck by a draper or slat conveyor. As

the kelp accumulates in the bow of the boat under the draper, it is hauled back by means of a grab-hook operated by a winch, so that the load is kept properly distributed as fast as it accumulates. This harvester carries a crew of six men—a captain, engineer, winchman, cutterman, and two hookmen. This is a seaworthy boat, and can operate in fairly rough weather. It has a speed of nine miles an hour, and in thick kelp can harvest fifty tons an hour.

On returning, the loaded harvester docks alongside the unloading pier underneath telpher track extending out from above a receiving hop-

per. A grab-hook, built like a clam-shell bucket, having a capacity of about 1500 pounds of kelp at a grab, unloads the barge, all lines being handled from a double-drum electric hoist. The unloading is done by an unloading crew of three men. About 30 tons an hour are unloaded in this way.

### CUTTING AND CONVEYING

This receiving hopper has but a moderate capacity, it being large enough to catch merely one grab-hook of kelp and feed it through a chopper (an ordinary ensilage chopper with certain extra controls) which cuts the



FIG. 1—THE "ALBION" LYING AT UNLOADING PIER

mapped and numbered the various areas capable of being harvested. The Commission exercises supervision over the beds, closing those which have been cut while they attain a regrowth, in such a way as to conserve the supply to the greatest possible advantage. Dr. W. C. Crandall of the Scripps Institution for Biological Research is a special deputy of the commission, and at the Institution scientists are making a thorough study of the growth and habits of kelp.

The chief manufacturers of kelp products are located at San Diego, Long Beach and Summerland (near Santa Barbara). The San Diego manufacturers harvest

kelp into lengths averaging about 12 inches. The chopped kelp drops into a drag conveyor, shown in Fig. 2, motor-driven at approximately 120 feet per minute, leading in three flights 700 feet in shore to a 300-ton hopper-bottomed storage bin. This storage bin is divided into two sections with a capacity of 150 tons each. The conveyor is merely a wooden flume with a pair of link chains along the bottom, to which cross-boards or slats are bolted at short intervals. The kelp itself is very slippery—its slimy exudation effectually lubricates the surfaces of contact between chain or flight and conveyor bottom.

In the above manner the kelp is cut, conveyed and discharged into an empty section of the storage bin as rapidly as it is unloaded from the barge.

Heaped kelp bleeds a yellowish, slimy substance, which contains about as much potash as the weed itself. This juice dripping from the storage bin is carefully caught on a tight subfloor, and drained into a concrete supply tank from which it is pumped into pans placed below and above the hot end of the rotary incinerators



FIG. 2.—VIEW FROM STORAGE BIN

and evaporated to dryness by the radiating heat which would otherwise be wasted. The solids remaining are a dark purple crystalline mass containing about 25 per cent K<sub>2</sub>O.

The V-shaped bottom of the kelp storage-bin is closed by a series of loose, horizontal boards, directly underneath which runs a drag conveyor such as formerly described, leading to the kiln room. One laborer is in the storage bin at all times, feeding or regulating the flow of the slippery sea weed to this conveyor. As the contents of the bin are unloaded back to a slope where considerable hoeing is required to keep a constant discharge, another one of the horizontal boards is removed at the toe of the slope. In this manner the bin is progressively emptied at a rate depending upon signals from the kiln room.

#### INCINERATING THE KELP

A stream of wet kelp coming in this manner from the storage bin is discharged into four rotary dryers by one of a pair of tilting-box feeders (Fig. 3), set between and above their hot ends. Thus at intervals of about 14 seconds either kiln receives a charge of 15 pounds

of material. The kilns themselves are merely unlined horizontal cylinders of steel plate, 42 feet long by 7 feet in diameter, set at a slight incline from the hot end downward toward the discharge end ( $\frac{1}{8}$  of an inch per foot), so that the contents will progress slowly forward as the cylinder rolls. Twelve rows of hooks, as shown

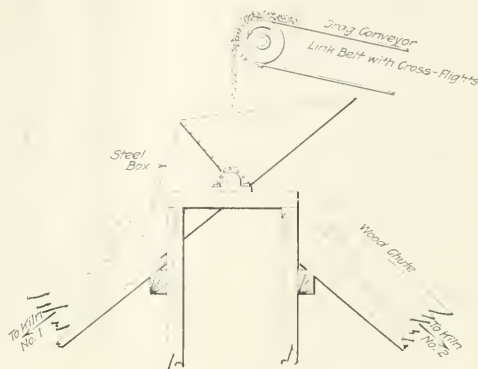


FIG. 3. TILTING BOX FEEDER

in the sketch, Fig. 4, are affixed to the interior of the shell in order to lift the wet shreds and drop them through the heated air within the kiln.

The kiln itself is fired by two oil burners, the fuel supply coming from wells in the immediate vicinity. The oil flame is confined within the limits of a relatively large "Dutch oven," 21 by 12 by 9 feet, set directly in front of the kiln itself. In this way a stream of gases of combustion and hot excess air enters the kiln, coming first in contact with the wet kelp at about 1400 deg. F. These gases partly dry the material in their passage, leaving at the far end loaded with moisture and cooled to a temperature of approximately 250

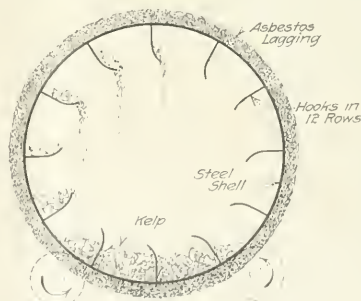


FIG. 4. INTERIOR KILN CONSTRUCTION

deg. F. The temperature of the exit gases is kept under constant observation by means of a recording pyrometer; should the temperature show a tendency to rise the feeder in the storage bin is notified to increase the flow of wet material, and *vice versa*. The moisture content of the weed discharged from these preliminary driers has been reduced from 90 per cent to about 25 per cent, the actual evaporation depending in large part upon the amount of work which can be performed in the incinerator, described later. The

appearance of the kelp at this point is markedly changed; the wet, green, slippery plant is now shriveled into dark brown, tough, leathery pieces, dry to the touch. Sometimes the leaves have burned to a char around the edges; these thin brittle borders are then pulverized during their travel through the kiln and are largely swept away with the furnace gases as dust. The moisture evaporated in these dryers is approximately 13 pounds per pound of fuel oil, using a fuel oil of 12 deg. Baumé, specific gravity 0.986, calorific power 18,500 B.t.u. per pound.

Two incinerators receive the discharge from the four dryers. These are merely rotary kilns 40 feet long and 5 feet in diameter, similar in construction to the preliminary dryer, except that they have no furnace or oven, the oil flame shooting directly into the drum. In this kiln the flame further dries the kelp and burns off the volatile hydrocarbons, producing a hot, grayish charcoal containing 35 per cent  $K_2O$ . The discharge falls into wheel-barrows and is immediately spread in long narrow ridges or "wind rows" on a cooling floor of concrete, where its heat quickly radiates into the atmosphere.

#### RECOVERY OF DUST FROM DRYERS

Furnace gases and moisture are drawn off from the rotary dryers by suction fans placed at the discharge end. The size of these fans averages 42 inches in diameter, with a capacity of 6000 cubic feet per minute, speed 900 r.p.m. Approximately 10 horsepower is required to operate each fan. A similar fan is used at the end of the incinerators to produce a draft necessary to complete combustion. Both in the preliminary dryers and in the incinerator a portion of the charge breaks into the finest particles, which are swept out by the furnace gases. This dust is of course quite valuable, and at the Lorned Manufacturing Co. the furnace flues lead to a series of brick dust chambers where the velocity is reduced to such a point that nearly all the dust is precipitated. At the end of the dust chamber the smoke passes through sprinklers to wash it thoroughly before allowing it to escape into the air. An average of 15 tons of dust, having a content of 30 per cent  $K_2O$ , is recovered from the dust chambers each month.

#### PRODUCT USED AS FERTILIZER

After the charcoal has cooled it is fed into a screw conveyor leading to the crushing plant, which is equipped with a Williams mill having a capacity of about 2000 pounds per hour. The resulting product, amounting to approximately six tons per day, is bagged on platform scales in sugar sacks containing 125 pounds each of fine ash. The sacks are stored until shipment in a nearby warehouse. A ready demand exists in the Southeastern fertilizer market.

The process as described above is admittedly crude. Many valuable products can be made from kelp, which are absolutely lost by this method. It has, however, the advantage that it produces potash, which is doubtless the one product most keenly needed just at present, in a plant readily operated without close technical control or a staff of highly skilled operatives.

As to the future of the industry, one may turn to various authorities. Meade<sup>1</sup> estimates that the efficiency

of the rotary dryers amounts to 70 pounds of water per gallon of oil, and that 1900 gallons of oil must be burned to produce one ton of potash. He therefore concludes that "the possibilities of the production of potassium salts from kelp on a large scale do not seem to be particularly bright as a post-war-time proposition. The cost of . . . fuel alone under ordinary conditions would eat up most of the price obtained for the product." On the other hand, Laucks<sup>2</sup>, citing his experience in drying kelp in the Northwest, quotes a harvesting cost of 42 cents per ton of kelp, unloading at 6 cents, and drying from 25 to 50 cents per ton of green kelp, using a rotary drier and hogged wood-waste as a fuel. Under these conditions, which evidently represent prices before the recent inflation, and which happily may be attained again, Laucks thinks that a product containing 28 per cent KCl, 2 per cent nitrogen, and 10 per cent water can be worked at a profit if the price for 80 per cent muriate remains above \$35 per ton. J. W. Turrentine, the government expert in charge of their experimental plant, on the other hand, writes,<sup>3</sup> "The giant kelp of the Pacific Coast still offers the best promise of supplying the proper conditions for the establishment of a domestic potash industry. Thus, they occur in sufficient quantity, they are accessible, and the product under normal conditions may be delivered at the market—the Atlantic seaboard—at a charge for freight that is not prohibitive."

The real truth may lie somewhat between these optimistic and pessimistic statements. Purely as a producer of potash by evaporating methods, kelp is at a distinct disadvantage against the Nebraska lakes. For instance, each has to evaporate about the same amount of water to get a ton of  $K_2O$ , and so far they have even chances; but it evidently costs much more to harvest a marine plant than to pump salt water. The future of kelp seems to lie in the recovery and use of the various by-products. The wet fermentation method developed with such marked success by the Hercules Powder Company,<sup>4</sup> produces potassium chloride, acetone, iodine, ethyl acetate, propionate and butyrate in commercial quantities, but requires a very expensive plant and high technical equipment. The dry distillation process now being developed by the United States Department of Agriculture in their experimental plant at Summerland, California, and in the forest products laboratory at Madison, Wisconsin, may prove more economical in first cost than the other. Potassium chloride, iodine, charcoal and distillates will be the chief products, and the success of their ideas will probably depend in large part upon the uses discovered for the latter two.

#### Potash and Kali

Kali, the German word for potash, comes down directly from Sanskrit, the ancient language of the Hindoos. Kali was their name for the black destroying goddess, who had numerous arms and red-palmed hands. Her eyes were red and her face and breast besmeared with blood. The name of the city, Calcutta, is derived from Kalighat, which, translated, means Kali's landing place. No doubt, Kali is just as plain and as representative a name for burned wood as our term potash.

<sup>1</sup>Ibid., March 15, 1916.

<sup>2</sup>Ibid., Feb. 15, 1917.

<sup>3</sup>Ibid., June 1, 1918.



# The Potash Industry of Germany

Theories of Origin and Description of the Strassfurt Salts Deposit—The Present Status of the Industry—Its Economic Aspect

By WALLACE SAVAGE

POTASH is one of the most abundant of the chemical elements, constituting about one-fortieth part of the mineral crust of the earth. In the formation of the fused glassy rocks such as the granites, micas and feldspars, it has contributed to a very great extent to their weather enduring properties, upon which the maintenance of land above sea level, the habitation of man, is largely dependant. How resistant these mineral potassium silicates have been to the ages of weathering in the past is obvious upon examination of the rocky peaks of the mountain ranges, or can be deduced from analyses of the ocean brine, the continental wash waters of all ages in concentration. Sea water will be found to consist essentially of sodium and magnesium salts in its three and one-half per cent of dissolved matter. Table I gives an analysis made by Regnault of the eight most important sea brine constituents.

TABLE I—ANALYSIS OF SEA WATER

|                          | Per Cent.<br>Solids | Per Cent.<br>Brine |
|--------------------------|---------------------|--------------------|
| Water.....               | 00 00               | 96 47              |
| Sodium chloride.....     | 76 49               | 2 70               |
| Magnesium chloride.....  | 10 20               | 0 36               |
| Magnesium sulphate.....  | 6 51                | 0 23               |
| Calcium sulphate.....    | 3 97                | 0 14               |
| Potassium chloride.....  | 1 98                | 0 07               |
| Calcium bicarbonate..... | 0 08                |                    |
| Magnesium bromide.....   | 0 06                | 0 03               |
| Miscellaneous.....       | 0 71                |                    |

However, judging alone from the preponderance of sodium, magnesium and calcium salts shown here, one could not derive numerical deductions, for a great part of the decomposition products of the minerals are absorbed largely and variously in animal and vegetable growth of an unknown amount. Table II gives the weights of salts in the ashes of normal crops from an acre of ground in the order of their average proportions.

TABLE II—POUNDS OF VEGETABLE ASH—ACRE CROP

|                 | Grain | Straw  | Roots  | Tops  | Hay   |
|-----------------|-------|--------|--------|-------|-------|
| Silica.....     | 14 71 | 233 08 | 27 03  | 2 67  | 78 23 |
| Potash.....     | 14 39 | 32 73  | 142 66 | 88 82 | 38 22 |
| Lime.....       | 2 24  | 27 62  | 46 24  | 72 14 | 44 45 |
| Phosphate.....  | 35 76 | 10 56  | 25 77  | 28 80 | 15 12 |
| Sulphate.....   | 0 12  | 13 15  | 46 24  | 38 81 | 9 20  |
| Chloride.....   | 0 02  | 3 55   | 12 24  | 49 75 | 4 06  |
| Magnesia.....   | 7 00  | 12 14  | 18 16  | 9 58  | 7 09  |
| Soda.....       | 7 05  | 1 21   | 17 31  | 16 76 | 12 05 |
| Iron oxide..... | 1 11  | 5 96   | 4 35   | 2 67  | 0 58  |

In the cycles of primeval vegetation, the mineral matter of all organic life was returned to the soil upon its inevitable decay at the place of growth. However, when man ceased to be an inhabitant of the forest, and the population became engaged in urban and agrarian pursuits, the extraction of the mineral salts from the soil began on an ever-increasing scale. Upon examining the table, the effect of the modern root crops, sugar beets and potatoes, in respect to potash, will be seen to be very great, 231 lb. being absorbed to the acre. Still more important did this become, when it was found that growth ceased as the available potash etc. became exhausted. In 1860, A. Frank, chemist in the sugar

refinery of Bennecke and Hecker at Stassfurt, worked out a process for extracting potassium chloride from the overburden salts, "abraumsalze," of the local rock salt mine, the two shafts of which had been completed in 1852. The manufacture of potash salts was then instituted, which became absolutely essential as a fertilizer to the German sugar beet, potato starch and alcohol industries.

## THE STASSFURT SALT INDUSTRY

During ancient times in Germany, before the era of the manufacture of iron pipes, salt was not transported long distances, but was obtained from the nearest brine springs, which were numerous, on account of the underlying strata of rock salt located there. In the lowlands north of the Harz Mountains, the flow of ground water toward the sea, due to the water head from the mountain slopes and the impervious strata formation of the soil, gave rise to many brine springs, the sodium chloride content of which, however, though not large, was exceptionally pure—the slight content of bitter foreign salts having been dissolved and entirely carried away from the leached residues of the deposits adjacent to the underground water currents.

Starting in about 1785, many wells were drilled in different parts of Europe. Prior to 1825, enormous beds of rock salt were located at many places in Wurttemberg, Hess, Baden, Lothringia, Langenberg, Kostritz, Koburg-Gotha, etc. Crude salt soon became so abundant that its main costs were in government tax fees and transportation charges. In 1839, the Konigliche Saline at Stassfurt gave up evaporating brine and began prospect work to determine the local availability of mineral salt as pure as that derived from their spring brine. In August, 1843, their drill struck salt at a depth of 832 feet, and after years of difficult work they drove into solid salt about 1000 feet, stopping on May 31, 1851, without reaching the base of the deposit. The well was a disappointment qualitatively, as the brine obtained from it had a very bitter taste.

Geheim Bergrat von Carnall decided that a shaft would be necessary to determine whether a separate layer of pure edible salt was situated at the source of the brine spring. Handelsmeister von der Heydt ordered two shafts sunk, which were started in the winter of 1851. At the ceremonies celebrating the opening, a crier went about Stassfurt calling: "Fellow citizens! Great opportunities will arise in the future for our industrial expansion! Just as there has been in the case of the sugar refinery, so will there be in this far more important undertaking!" How majestically this prediction was to be fulfilled could not have been foreseen in these days of wood fuel and ample supplies of potash from wood ashes. It was exactly these accompany-

ing mineral salts, potassium and magnesium chlorides, an undesired impurity in table salt and without a market at the time, which were to become the corner stone of German strength in international commerce in chemicals, the absence of which were indicated initially by the purity of spring brine, because in reality, they were sealed from the ground water by impervious strata of clay and gypsum but for the protection of which they would long since have been dissolved by the ground water and disseminated far and wide.

#### PROSPECTING THE STASSFURT DEPOSIT FOR POTASH

From the amount of boring that followed in subsequent years, the deposit of potassium salts appears to cover an area of one hundred square miles, principally located in Anhalt and Prussian provinces of Saxony and Hanover. At an early date Anhalt, recognizing the agricultural and financial value of such deposits, declared the rights of exploration a state monopoly, which was later contracted to a few private companies. In Saxony, prospecting rights were free and the mining concessions belonged to the first discoverer of the deposits without regard to the owner of the surface soil. According to the laws of Hanover, the property holder owns all the mining rights.

Under such a variety of laws, the deposit has had unhampered exploitation. Speculators have paid as high as \$12 per foot for diamond drill cores to establish their claim for concessions. Stock companies were formed in great numbers. The older companies, fearing overproduction and falling prices, banded together against newcomers. The earlier members of the syndicate, with the year of their starting mining and their production allotments for the four following divisions are given in Table III.

- Class I Products more than 48 per cent K<sub>2</sub>O.
- Class II Products 48-18 per cent K<sub>2</sub>O.
- Class III Products 18-12 per cent K<sub>2</sub>O.
- Class IV Products less than 12 per cent K<sub>2</sub>O.

TABLE III—KALI-SYNDICATE (1900)

|                                                            | I   | II          | III | IV  |
|------------------------------------------------------------|-----|-------------|-----|-----|
| Der königlich preussische Fiskus, Stassfurt, 1852.....     | 150 | 130         | 130 | 142 |
| Der herzoglich anhaltische Fiskus, Leopoldshall, 1857..... | 118 | 118         | 120 | 110 |
| Consolidirte Alkaliwerke, Westeregeln, 1871.....           | 100 | 100         | 102 | 100 |
| Salzbergwerk Neustassfurt, Stassfurt, 1877.....            | 100 | 100         | 102 | 100 |
| Gewerkschaft Ludwig II, Stassfurt, 1881.....               | 72  | 72          | 26  | 80  |
| Kaliwerke Ascherleben, Ascherleben, 1882.....              | 100 | 100         | 102 | 100 |
| Gewerkschaft Hiereynia, Vienberg, 1884.....                | 93  | 93          | 101 | 100 |
| Deutsche Solway-Werke, Bernberg, 1885.....                 | 100 | 100         | 102 | 100 |
| Thierdall, Thiede, 1885.....                               | 46  | 46          | 48  | 48  |
| Willhelmshall, Aulerbeck, 1887.....                        | 61  | 61          | 85  | 70  |
| Gewerkschaft Gluckauf, Sonderhausen, 1893.....             | 40  | 40          | 70  |     |
| Gewerkschaft Hildwigsbau, Wendessen, 1895.....             | 40  | 40          | 60  | 50  |
| Gewerkschaft Burbach, Beesdorf, 1897.....                  |     | Independent |     |     |
| Schmiltzmannhall, Leopoldshall, 1883.....                  |     | Independent |     |     |

#### THEORY OF THE FORMATION OF THE STASSFURT SALT DEPOSITS

The colossal size of the salt deposits which have been disclosed in Northern Europe has created much speculation upon the part of geologists and chemists as to the manner of their formation. For detailed discussions on the subject, the reader should consult the German treatises<sup>1</sup>.

Summarizing the studies of his predecessors, C. Ochenius explained the origin of the deposit by the evaporation of sea brine in land-locked basins near the

ocean shore at the time of the Permian formation, which bodies of water were shut off from the open ocean by sand bars at the connecting inlets, thus forming land-locked salt lakes. Such a formation can be seen at the present day on the east side of the Caspian sea. The surface of this Caspian lake, which is connected to the open sea by a shallow canal 225 yards wide and 1 yard deep, is 585 square miles in area with a depth of 16 yards. In the summer a thick layer of salt crystallizes out. Upon comparison of the solubility curves in Chart I with the analysis of sea water, Table I, it will be seen that ocean brine is 10 per cent saturated with sodium chloride and only 1 per cent with magnesium chloride. While intra-ionic and physical af-

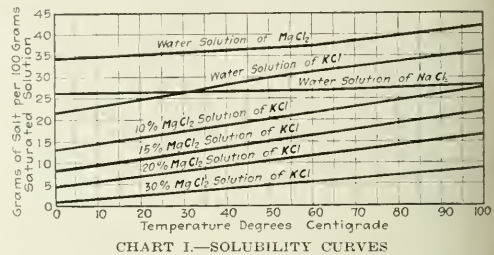


CHART I.—SOLUBILITY CURVES

fects vary the solubility of these salts in the presence of each other, it can be readily seen that a dead sea would have to be concentrated one hundred times by means of evaporation and decrease in volume, due to the space occupied by the deposited sodium chloride, before the bitter salts would separate from their solution.

Upon inspection of the salt deposits at Stassfurt, thousands of segregated strata of salt from 3 to 4 inches thick will be found. During the changes in the weather, when probably the "September gales" dashed the sea over the inlet bars, new brine charged with lime salts entered the dead sea and there was immediately deposited a thin blanket of anhydrite (CaSO<sub>4</sub>) which has become known as the year ring from analogy with the lines in tree growth. The number of these rings indicates that ten thousand years were occupied in the deposition of the rock salt and in the accumulation of the saturated solution of magnesium and potassium salts.

Finally, either the bars grew to greater size or the weather grew milder and the barriers completely isolated the lake of accumulated minor brine salts from the ocean. Polyhalite (K<sub>2</sub>SO<sub>4</sub>, 2CaSO<sub>4</sub>, MgSO<sub>4</sub>, 2H<sub>2</sub>O) first crystallized, then kieserite (MgSO<sub>4</sub>, H<sub>2</sub>O), next carnallite (KCl, MgCl<sub>2</sub>, 6H<sub>2</sub>O), and then fortunately clay, gypsum, sandstone and diluvial and alluvial formations sealed the deposit securely as is shown in Fig. 1 of the Leopoldshall deposit. The period for the entire formation down to the 3300-foot level of the salt deposit has been estimated at about 15,000 years.

A few investigators believe that the ocean was not the source of the brine and that the salts were the direct decomposition products of the rocks from the Harz Mountains. An example is offered at present in the case of the historic Dead Sea and the river Jordan. In recent times van't Hoff, in cooperation with many other chemists made an investigation on the crystal-

<sup>1</sup>Beschof, "Die Steinsalzwerke bei Stassfurt." E. Pfeiffer. "Handbuch der Kalindustrie." Furer. "Salzbergbau und Salinenkunde." Frecht, "Die Norddeutsche Kalindustrie." Ochenius, "Die Bildung der Steinsalzlager und ihrer Mutterlaugensalze." Walther, "Das Gesetz der Wurtenbildung." Van't Hoff, Sitzungsber d. Kgl. preuss Akad. d. Wissenschaft. Zu Berlin 1897-1908; "Zur Bildung der Ozeanischen Salzlagernungen."

For this reason, hot solutions and cold crystallizations are made, the temperature increasing the solubility several per cent of both these salts. Sodium chloride does not become materially more soluble upon boiling, so that what dissolves does not crystallize out on cooling, but passes away with the mother liquor. The scheme of the process used in the average refinery is given diagrammatically in Chart II. Sylvine is a secondary salt found at many places where ground water has had limited access and has carried off the more soluble magnesium salts, leaving sodium and potassium chlorides. This is easily refined by solution in hot brine, potassium chloride being alone supersaturated upon cooling. While many elaborate types of digesters have been developed for use in this industry, space will not be taken for their description.

About nine years ago there arose an illuminating price controversy between the Schmidtman Company

temperatures during the period of formation was from 77 to 163 deg. F. If the brine corresponding to the deposited salts should be superimposed over the deposit, it would be fifty miles deep, which would indicate that an average of one rod of water was evaporated annually. Reasoning from such figures, one is led to con-

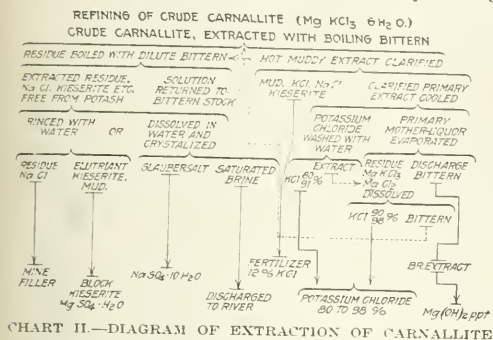


CHART II.—DIAGRAM OF EXTRACTION OF CARNALLITE

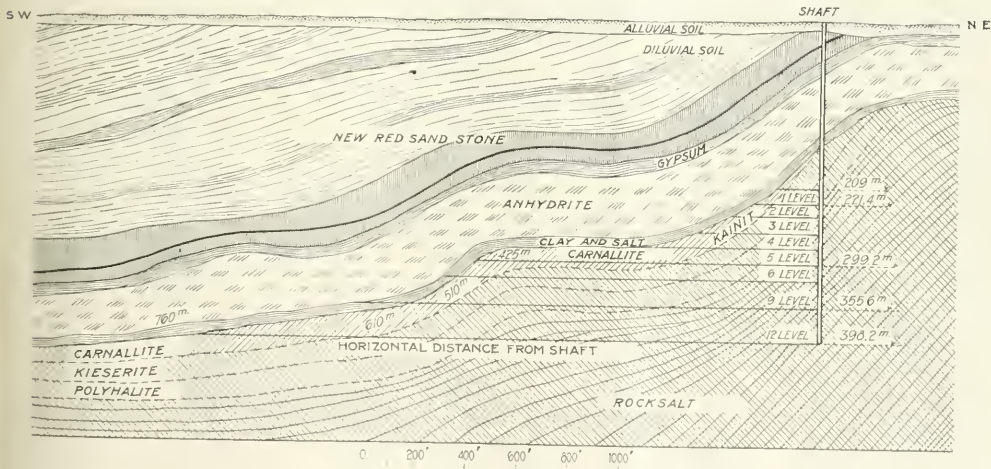


FIG. 1.—CROSS-SECTION OF THE SALT DEPOSIT AT LEOPOLDSHALL.

and the syndicate. Table V gives the wholesale prices for 1910 contracts made for American imports. It is

## TABLE V—WHOLESALE PRICES PER LONG TON—1910

|                           | Schmidtman<br>F.o.b.<br>MINE | Cif.<br>U. S. A. | Syndicate<br>Net<br>C. f.<br>U. S. A. |
|---------------------------|------------------------------|------------------|---------------------------------------|
| Concentrated salts.       |                              |                  |                                       |
| Muriate .....             | \$15 54                      | \$20 40          | \$32 98                               |
| Sulphate .....            | 20 94                        | 25 80            | 38 80                                 |
| Double manure ..          | 9 28                         | 14 14            | 20 37                                 |
| Thirty per cent manure .. | 8 42                         | 13 28            | ...                                   |
| Crude salts:              |                              |                  |                                       |
| Kainit ....               | 1 92                         | 5 16             | 7 03                                  |
| Martozul .....            | 2 40                         | 5 12             | 8 73                                  |
| Twenty per cent manure .. | 3 89                         | 7 13             | 11 64                                 |

TABLE IV—ANALYSIS OF CRUDE CARNALLITE

|                    | Per Cent |
|--------------------|----------|
| Water              | 26.2     |
| Sodium chloride    | 21.5     |
| Magnesium chloride | 21.3     |
| Potassium chloride | 15.6     |
| Magnesium sulphate | 13.0     |
| Gypsum             | 2.0      |
| Miscellaneous mud  | 0.4      |

Crude salts:

|                        |      |      |       |
|------------------------|------|------|-------|
| Kainit. ....           | 1.92 | 5.16 | 7.03  |
| Martsalz .....         | 2.48 | 5.72 | 8.73  |
| Twenty per cent manure | 3.89 | 7.13 | 11.64 |





# The Cottrell Process for Potash Recovery\*

## A Description of the Collection by Electrical Precipitation of the Volatile Vapors of Alkali Salts from Iron Blast Furnaces and Cement Kilns

By LINN BRADLEY

Chief Engineer of the Research Corporation

THE subject of potash recovery is becoming of more universal interest to the public as well as to the technical man. The daily press and the magazines frequently refer to what is being done and to what should be done in this country in order to offset and decisively defeat the Kaiser and his followers. Recently several news items and editorials have appeared in the metropolitan press calling our attention to what is being accomplished in England toward making their country independent of Germany, and it appears that the British Government has furnished large sums of money to assist in recovering potash from their iron blast furnace gases. It is predicted that this source will enable England to obtain enough potash to equal her entire pre-war importation from Germany. France is reported to be as keenly awake to the possibilities along this line and we may see the time when France will be recovering large quantities of potash from iron ores which Germany has made such strenuous efforts to control. However, it is not surprising that interest in potash should increase, when we consider that this is the one big economic weapon which Germany has relied upon to regain her place in the sun after the war. She boasts that all countries will have to depend on her for potash. She claims that other countries can not produce potash to compete with that supplied by Germany. But in this as in many other instances her reasoning is based on lack of information as to facts and possibilities.

The recovery of potash in this country is making rapid strides. The industry may be roughly divided into those plants in which the recovered potash is the main product and those in which the potash is recovered as a by-product. In this paper the latter phase will be considered as it is believed that while the largest immediate tonnage may be obtained from desert lakes, kelp, alunite and a few other sources, nevertheless a study of the economic problems will show that the surest way of making our potash industry a permanent and enduring one, able to supply all of our requirements even against German competition, is to develop and rely upon the by-product potash.

### FIRST CEMENT PLANT INSTALLATION

After the installation of the Cottrell processes at the plant of the Riverside Portland Cement Company in California was placed in operation for the purpose of eliminating the dust nuisance, it was noticed that the material collected in various parts of the precipitator differed in fineness. Natural inquisitiveness then called for an analysis of these products to determine if any

impurities in the raw mix had become concentrated in any portion of the dust. The alkalies increased with the fineness of the material as shown by screen analyses. At that time considerable light fume was escaping from the precipitator exits and the suggestion was made and urged that some of this material be collected and analyzed as it might show even higher alkali content, since having been interested in agricultural and fertilizer problems it seemed to some of us that potash might be found in the escaping fume in percentages such as would warrant its recovery. Thus the first commercial potash recovering plant in this country was established. The engineer in charge of this work was Mr. W. A. Schmidt of Los Angeles. Since that time a number of improvements have been developed and the commercial success of the potash plant at Riverside has been the cause of several other cement plants installing potash recovery plants.

### INVESTIGATION MADE ON BLAST FURNACE DUST

Early in 1912 the Research Corporation of New York started to develop the Cottrell processes and apply them to various plants in the eastern portion of the United States. Shortly after work had been begun, a paper was read and a demonstration given at a meeting of the local section of the American Chemical Society near Allentown, N. J. The next day arrangements were made for a visit to the South Bethlehem plant of the Bethlehem Steel Company. Having in mind the experiences of the Riverside cement plant, curiosity was aroused by the appearance of the gases coming from the tall brick stack connected to the boilers. An investigation was undertaken by Mr. R. J. Wysor and this resulted in extensive investigations thereafter to determine the possibility of cleaning these gases by the Cottrell processes and recovering whatever of value could be obtained from the collected material. Mr. Wysor has published a very able and valuable article in the *Transactions of the American Institute of Mining Engineers* (1917) giving a great deal of data on ores, fluxes, slags, potash balances and other items directly related to the recovery of potash as a by-product of blast furnaces. His paper probably served as an inspiration for much of the work which has been undertaken abroad.

Analyses of iron ores, cokes, limestones and dolomites show a wide variation in potash content, and it is therefore advisable for one interested to make sure that his raw materials are sufficiently rich to warrant a potash recovery plant. Furnaces which produce a large tonnage of slag per ton of iron on account of the iron content of the furnace charge will, of course, carry more potash into the slag than furnaces which produce

\*A paper read at the Fourth National Exposition of Chemical Industries, New York City, September 25, 1918.

a relatively small volume of slag, other things being equal except for composition of the charge. Some iron ores carry as high as 60 per cent of iron and are practically devoid of potash. Some coke have a low ash and are low in potash. Some limestones and some dolomites may be quite pure. If, therefore, the ores are uniform and properly prepared and the fuel and flux are properly proportioned, the slag volume will be small and the potash in the gases may likewise be negligible. On the other hand, if the iron ore carries as much as two or even one per cent of potash ( $K_2O$ ) and the coke ratio is high and it and the flux contain as much as .25 to .50 per cent of potash, quite a large quantity of potash will be volatilized and carried off by the gases from which it can be recovered. The high temperature in the blast furnace and the length of time under treatment allows the silicates to be decomposed more readily than in a cement kiln where the temperatures are not so high. The potentialities of the by-product recovery from blast furnaces would, therefore, seem to surpass the possibilities of the Portland Cement Industry in this regard.

Numerous attempts have heretofore been made to recover potash from silicate rocks. The investment and operating cost, especially for fuel, are hard to overcome if one endeavors to volatilize the potash and recover it and nothing else. It therefore seems that the best way to recover the potash from these silicates by heat treatment is to charge these silicates into existing furnaces along with the regular charge and recover the potash as a by-product, thus eliminating the investment and operating cost for new and separate furnaces. This would be profitable up to a certain point, beyond which this practice would, however, not be desirable.

Since the investigations referred to were begun at South Bethlehem, numerous other furnaces have been investigated and potash balances made. Iron ores have been found in abundance in Alabama which carry from one to as high as three per cent in potash and carry enough iron to make them highly suitable for this purpose. The following tables show the results of one investigation.

#### PERCENTAGE ANALYSES OF MATERIALS

| Material  | Fe    | $SiO_2$ | $Al_2O_3$ | $CaO$ | MgO  | Ash   | Carbon | $Na_2O$ | $K_2O$ |
|-----------|-------|---------|-----------|-------|------|-------|--------|---------|--------|
| Ore No. 1 | 46.36 | 17.42   | 4.19      | 5.03  | 8.33 | ..... | .....  | 0.62    | 1.27   |
| Ore No. 2 | 54.69 | 12.78   | 3.49      | 4.04  | 6.00 | ..... | .....  | 0.39    | 0.74   |
| Stone     | ..... | 1.56    | 0.58      | 46.24 | 7.25 | ..... | .....  | 0.64    | 0.26   |
| Coke      | ..... | 5.82    | 3.49      | 0.51  | 0.24 | 13.01 | 86.15  | 0.39    | 0.32   |

#### CHARGED INTO BLAST FURNACE

| Materials | lb. per Ton Iron | Total lb. $K_2O$ | Per Cent. of Total |
|-----------|------------------|------------------|--------------------|
| Ore No. 1 | 3,115            | 39.56            | 61.0               |
| Ore No. 2 | 1,168            | 8.65             | 13.2               |
| Stone     | 1,440            | 3.74             | 5.8                |
| Coke      | 4,059            | 12.97            | 20.0               |
| Total     | 9,773            | 64.92            | 100.0              |

#### SUMMARY

|                                                                                                      |       |
|------------------------------------------------------------------------------------------------------|-------|
| Total $K_2O$ charged into furnace per ton of iron produced, lb.                                      | 64.92 |
| Lost in slag per ton of iron produced, lb.                                                           | 11.60 |
| Lost as fume from gas leaks per ton of iron produced (estim.), lb.                                   | 1.16  |
| Total potash recoverable from gases per ton of iron produced, lb.                                    | 52.16 |
| Total potash in dust in gases as per analyses, per cent                                              | 34.11 |
| Water soluble potash in dust in gases as per analyses, per cent                                      | 32.10 |
| Portion of total potash in dust, which is water soluble, per cent                                    | 94.11 |
| Total water soluble potash recoverable per ton of iron by collecting the dust in the flue gases, lb. | 49.09 |

|                                                                                                                   |          |
|-------------------------------------------------------------------------------------------------------------------|----------|
| Total water soluble potash as above per 500 tons iron per day, lb.                                                | 24545.00 |
| Total water soluble potash as above per year of 350 days, tons                                                    | 4295.37  |
| Portion of total potash charged into furnace which is recoverable from gases in water soluble condition, per cent | 75.62    |
| Safe estimate of above amount recoverable in operating practice, per cent                                         | 80.00    |
| Safe estimate of above amount recoverable as above per year of 350 days, tons                                     | 3436.29  |

A study of the above figures will show that it is desirable to keep the potash content of the raw materials up to the highest point and to keep the slag volume and potash content as low as possible. It is clear that if the slag volume remained constant as well as its analysis that if only 11.6 pounds of potash had been contained in the furnace charge there would have been nothing available for collection. With suitable slag volume and potash content and a rich potash charge, the recovery of potash in quantities worth while is readily obtained. Sodium chloride has been found helpful in liberating the potash in such way that it is recoverable in the dust in a water soluble form. While working at a cupola furnace in which sash weights were made from old tin cans and other metal waste, it was found that the use of common salt, sodium chloride, greatly increased the fume volume and density and this later was shown to be due to the fact that chlorides of lead, tin and zinc were formed and readily volatilized as such. The use of salt has been extended to cement kiln practice and to other uses in connection with the recovery of silver, lead and zinc from low grade ores and tailings, the values being recovered from the gases after volatilization as chlorides.

Consideration of data such as presented in the tables given below resulted in an effort being made to find raw materials suitable for making iron and yet carrying high percentages of potash. Samples of ores, fluxes and coke were obtained from a number of furnaces and other sources, and later on this work was carried on much more extensively by the Bureau of Soils of the Department of Agriculture. It is probable that Mr. Frederick Brown of that Bureau has now collected data on nearly all of the raw materials available for iron making and that if such data were made public in the near future, it would be of great assistance in connection with the problems under consideration. Personal efforts to find materials such as described developed the fact that in the eastern part of Alabama there is a very large tonnage of iron ores carrying in some cases an average of one per cent of potash and in other instances an average of about 1.80 per cent of  $K_2O$ , several analyses showing a content of over 3 per cent  $K_2O$ . I am indebted to Dr. J. S. Grasty for having brought these ores to my attention and for much of the data on their iron and potash content as given later in this paper. Mr. M. W. Bush, President Shelby Iron Company has also contributed data on the iron situation of the South and the values of these iron ores in furnace operations. I have examined these properties and have interviewed blast furnace operators who have used them in their furnaces and hold the opinion that they constitute an asset of importance to the nation as well as to interested parties. They should receive the consideration of the Government in connection with our war



problems and likewise our post-war problems so as to assist in rendering our country absolutely independent of Germany. The ores carry an average of from 48 to 52 per cent of iron, are very uniform, easily mined and shipped as they are directly on the railroad, and operate satisfactorily in the furnace producing good iron at low cost. Their potash content also acts as a desulphurizer, thus improving the grade of iron. The phosphorus content is very low.

The following table has been compiled to show the economic importance of these ores as a source of potash, the figures having been based on experience at several other furnaces as well as on the data obtained in connection with these particular ores and at various iron furnaces in the South. The tables has been submitted to experienced iron blast furnace operators for suggestions and criticisms. For comparison, other ores have been included in the table. The composition of the high-potash iron ore has been taken from the average of over one thousand tons of such ore shipped to furnaces on which  $K_2O$  was determined for each car of this particular shipment.

PERCENTAGE CONTENTS

|                                                      | Coke | Stone | No. 1<br>Gray | No. 2<br>Red | No. 3<br>Brown |
|------------------------------------------------------|------|-------|---------------|--------------|----------------|
| Silica $SiO_2$ .....                                 | 8.70 | 2.00  | 19.2          | 15.0         | 19.5           |
| Alumina $Al_2O_3$ .....                              | 5.00 | 1.00  | 4.8           | 4.0          | 4.8            |
| Lime $CaO$ .....                                     | 0.30 | 53.00 | 1.3           | 17.0         | 6.0            |
| Potash $K_2O$ .....                                  | 0.30 | 0.30  | 1.8           | 0.2          | 0.2            |
| Iron Fe.....                                         | 1.70 | 0.00  | 49.8          | 36.0         | 42.0           |
| Ore required for one ton iron, lb.....               |      |       | 4398          | 6039         | 5212           |
| Percentage of burden.....                            |      |       | 46.07         | 54.35        | 46.87          |
| Coke required for one ton iron, lb.....              |      |       | 2700          | 3900         | 3000           |
| Percentage of burden.....                            |      |       | 28.29         | 35.22        | 26.98          |
| Stone required for one ton iron, lb.....             |      |       | 2448          | 1159         | 2909           |
| Percentage of burden.....                            |      |       | 25.64         | 10.43        | 25.15          |
| Total potash content of burden per ton iron, lb..... |      |       | 99.5          | 29.57        | 33.97          |
| Deduct for losses in slag and elsewhere.....         |      |       | 10.4          | 15.6         | 14.0           |
| Total potash collectible from gases, lb.....         |      |       | 89.1          | 13.97        | 19.97          |
| Slag volume per ton iron, lb.....                    |      |       | 2715          | 3290         | 3090           |
| Total potash in gases per day (500 tons iron).....   |      |       | 44550         | 6985         | 9985           |
| Total potash in gases per 350 day year, tons.....    |      |       | 7796          | 1222         | 1747           |
| Assume eighty per cent recovery, this equals.....    |      |       | 6237          | 978          | 1406           |
| Value per annum at \$500 per ton of $K_2O$ .....     |      |       | \$3118500     | 489000       | 703000         |
| Value per annum at \$100 per ton of $K_2O$ .....     |      |       | 623700        | 97800        | 140600         |

The total production of pig iron in this country is such that about 200 furnaces of such size as referred to above would be required to meet our requirements if the furnaces were of the same capacity. So it is easy to see that we now have sufficient furnace capacity to produce annually over 1,500,000 tons of potash per annum, far in excess of our pre-war requirements. The difficulty lies in the fact that we have not found that all furnace burdens carry the amount of potash shown under the No. 1 column. If the furnace charges and operations could be adapted so that one-fifth of the amount, or 300,000 tons, could be produced this would meet our needs without assistance from any other source. The three constituents of the charge, ore, stone and coke, contain more or less potash. By using those raw materials which carry more than usual amounts of potash, our recoveries can be considerably augmented. In cases where ores are smelted which are excessively limy, feldspar, potash bearing slate or

other potash bearing silicates could be fed into the furnace and thus increase the potash content of the furnace burden.

#### BY-PRODUCT POTASH FROM FELDSPAR CEMENT

Mr. H. E. Brown, a chemical engineer of New York City has developed a process for making a special cement from the slag obtained from a blast furnace and at the same time recovering water soluble potash from the gases. He charges limestone, coke and feldspar into the furnace. Now if iron ores of suitable kind could be used for a portion of the raw material, it might be possible to produce potash from the gases, also pig iron, and a slag which could be readily converted into a marketable cement. As the market varies with the supply and price, the furnace charge could be varied so as to increase the potash and reduce the iron or vice versa. The process has been developed to the extent that both potash and the special cement can be produced but investigations looking to a reduction in the operating cost have not been completed. It appears, however, that with an assured market for the cement at fair prices, the process can be operated successfully and show a good return on the investment, especially when the price for potash is high. In this connection, it seems that consideration might well be given to the use of powdered coal introduced through the tuyeres and thus reduce the coke required and possibly doing away with it all together. It would materially reduce operating costs and increase production and recoveries.

#### POTASH FROM THE GEORGIA CAMBRIAN SLATES

It is natural to look to feldspar and other potash bearing silicates for our potash. The cost of mining and grinding feldspar is one obstacle to be overcome which is not an obstacle for instance in the Cambrian slates of Georgia. It has been suggested also that efforts be made to recover potash from the tailings dumps in the Cripple Creek District of Colorado, these tailings carrying as high as 7 per cent of  $K_2O$ . Investigations as to the feasibility of this are now under way. Sufficient progress has not yet been made, however, to warrant any very optimistic statements. The fuel cost and the necessity for a long freight haul to the fertilizer consuming districts are large items to overcome.

Sericites and Cambrian potash bearing slates have been located in Georgia which carry potash in considerable quantity, several deposits analyzing as high as 8 per cent or 9 per cent. Laboratory investigations have shown that the potash in these raw materials was more readily rendered water soluble or volatilized by treatment with salt in a rotary kiln than the potash from feldspar. Furthermore, the amount of lime required to be added to the charge before the potash is liberated appears to be much less than required for feldspar. The cost of production is much less than in the case of feldspar and the cost of grinding is very much less and altogether these slates are much better adapted for the purpose here discussed than feldspar is. Dr. T. P. Maynard of Atlanta, Georgia, who conducted these researches and developed the properties, reports that there is an enormous tonnage available. It is also reported that a company has been treating this material in a rotary kiln, adding 200 to 300 pounds

of salt per ton of raw material, volatilizing a good portion of the potash and converting a large percentage of the balance into a water soluble compound in the clinker. Freight rates should be very low since this material is located very close to a large market, namely the cotton fields of Georgia and Alabama. Engineers state that cotton grows prolifically on these lands without any additional fertilizer, indicating the ease with which the potash is made available.

#### COTTRELL PROCESS INSTALLATIONS IN CEMENT PLANTS

In all of the cases mentioned above, potash is volatilized and must be recovered from the gases. The Cottrell process has met with excellent success in this phase of potash recovery problems. The field of application which has been developed the farthest is in the recovery of potash from cement kiln gases. Several plants are now in successful operation and at the present time a considerable tonnage is being obtained in this manner. Other plants are under construction and the outlook for a much larger tonnage is very favorable. In the August 21 issue (1918) of *The American Fertilizer*, published at Philadelphia, Penn., John J. Porter, General Manager of the Security Cement and Lime Company of Hagerstown, Maryland, in an article entitled "The Recovery of Potash as a By-Product in the Manufacture of Portland Cement," gives a great deal of valuable information upon this problem. The following is quoted from that article. "Estimating Potash Recovery." For the benefit of those who may wish to figure on their own conditions, I give the following method of calculating the probable recovery of potash:

- Let A equal per cent potash in raw mix.  
 B equal per cent potash in clinker.  
 C equal per cent liberation =  $600A - 380B \div 600A$ .  
 F equal lbs. of potash recombinced per bbl. clinker = 0.7 to 1.5.

depending on fuel consumption and per cent ash in coal.

Let P equal per cent potash precipitated in treaters.

Assume 600 lb. of raw mix actually used to make 1 bbl. of clinker,

then—Lb. of potash entering kilns per barrel of clinker equals 600A.

Lb. of potash volatilized in kilns per barrel clinker equals 600 AC.

Lb. of water soluble potash entering treaters per barrel clinker equals 600 AC-F.

Lbs. of water soluble potash collected in treaters per barrel clinker equals  $(600AC-F) \times P$ .

The cost of collecting potash at Security is now running about as follows:

|                                                                  | Per Unit of Potash |
|------------------------------------------------------------------|--------------------|
| Collection, including labor, power, repairs and laboratory ..... | \$0.14             |
| Packing and shipping .....                                       | 0.08               |

Total operating cost exclusive of depreciation, royalty and salt addition.....\$0.22

The cost of the salt addition is about \$0.25 per unit of potash, but this is not a necessary element of cost and can be omitted whenever price conditions become such as to give an unsatisfactory margin of profits.

The article then goes on to show that from a 3000 barrel cement plant, the operating profit per annum on the potash alone comes to about \$458,000, the raw mix having 0.75 per cent of potash. The article is quite complete and those interested are referred to it for further details. The Bureau of Soils published the results of their survey of cement plants. The data given indicates that this industry can be counted on to

furnish 80,000 to 100,000 tons of potash annually. By using materials which are higher in potash content, such as feldspar, sercite or slate in part, the yield of potash can be materially increased. The additional cost for raw material should be weighed against the greater financial return from the plant operation as a whole and not allow first cost per ton of material to govern. The utilization of existing cement kilns and equipment for the manufacture of cement as a by-product, placing special emphasis on the potash yield and profits therefrom, should be urged by all citizens, and this should be more emphatically urged for the recovery of potash from blast furnace gases. The feat of obtaining all of our potash from existing industries by recovering the by-products will be typically American and worthy of our "Yankee ingenuity." The by-product method will enable us to compete with potash from any other source, and the Kaiser's vain boasts that all countries will be compelled to submit to his will because they must have his potash, shall receive their proper answer.

#### POTASH PROSPECTS IN THE IRON INDUSTRY

Referring again to the iron industry and its relation to the potash question, it should be pointed out that in the Alabama district there is an abundance of excellent coal, labor is plentiful and cheap, and the climatic conditions are such that the district may be considered an all year one as far as operating is concerned. Then, when it is realized that there is immediately at hand an enormous tonnage of high grade iron ore which carries such a large potash content and that the South produces our cotton and therefore is the large consumer of potash and thus provides a large market within a few miles, the economic importance of this situation can be better appreciated. Other iron ores contain potash, some of which may justify recovery plants, and we should be on the lookout for such materials, keeping in mind that our goal is to obtain our potash as a by-product at such a cost as will enable us to ignore Germany forever and thus make the dreams of the American chemist and engineer come true.

The South produces pig iron cheaper than any other district in normal times. In fact their furnaces must do this in order to stay in the market. The South does not yet consume as much iron and steel products as its population justifies and therefore their iron must carry a high freight charge if it is shipped North to the larger markets. The manufacture of cast iron pipe has, however, grown to a large industry. In the future more and more iron and steel will be consumed locally as it is evident that the South is coming into its own very rapidly. The additional profit which can be obtained from the potash will be of great assistance in keeping their iron furnaces in blast when the market sags. The South has a very fortunate combination of labor, raw materials, climate and a large and near fertilizer market. In France and in Great Britain the Governments have taken an active interest in the possibilities along the lines herein pointed out. It has been reported that investigations extending over a period of three years have shown that Great Britain can produce enough potash to satisfy all her requirements.

## Potash from Alunite in Utah

BY JOHN W. HORNSEY

THE arbitrary action taken by the German Government some years ago in forcing Americans who had purchased interests in German potash works to join the German Potash Syndicate and the lack of tact displayed by those who handled the situation for Germany, created so much ill feeling that all together it brought about the determination upon the part of the United States Government and of American buyers to find some source of potash other than the German, and plans were thereupon made for both governmental and independent searches. Fortunately for this country, when war was declared in 1914 these searches had developed a large amount of valuable data.

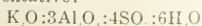
Both the Geological Survey and the Bureau of Soils were granted appropriations and began active work, which has proved to be of considerable value. However, the independent investigators made a somewhat more comprehensive survey without going quite so exhaustively into details, except where it seemed reasonably certain that a commercially workable supply would be found.

All probable sources of supply were investigated, including feldspar, kelp, desert lakes, leucite and alunite. It was evident from the start that potash could not be produced profitably at anti-war prices from certain of these materials without the production and sale of by-products, and for some of these by-products there was only a limited market. In other cases a somewhat more careful study of the subject showed that potash was unquestionably the by-product. This work has, however, definitely resulted in the development of a permanent potash industry in this country, and I say permanent advisedly, for some of the plants will, undoubtedly, be able to continue after the war.

### ALUNITE

Many centuries ago alunite was mined in Smyrna and for about 400 years in Italy and was used for the production of potash alum. When the search for potash began in this country, it was felt that a deposit of alunite might be found and that it might be used as a source of potash rather than potash alum. About this time such a deposit was discovered in southern Utah, a few miles from Marysvale. Later it seemed that it would be necessary to discover some means of refining the alumina before potash could be produced in competition with Germany. However, early in 1915 when the price of potash had risen to what seemed impossible figures, Mr. Howard F. Chappell and his associates of the Mineral Products Corporation decided to build a plant, and this has been in continuous and successful operation for three years, except for two shut-downs of one or two months each caused by fires. They are now producing and shipping about 600 tons of sulphate per month, and the product is considerably better than 90 per cent pure.

Several formulas are given by various authorities to indicate the chemical composition of alunite a double sulphate of potassium and aluminium, of which the following is representative:



The above formula appears to be nearly correct, i.e., for the alunite now being worked at the town of Alunite near Marysvale. Several methods have been proposed for the treatment of an ore of this character for the production of potash, but probably the simplest one is that employed in this plant where the ore is calcined at approximately 1000 deg. C. This drives off water of crystallization and sulphuric acid, leaving water soluble potassium sulphate and alumina. Upon leaching and evaporation of the resulting solution, potash is recovered as sulphate with a very small percentage of soda and some infinitely fine alumina which has passed through the filter cloths.

The alunite from the Mineral Products Corporation's mine is of a distinctly crystalline nature and from 96 to 97 per cent pure alunite. There are other large deposits nearby but they are more nearly amorphous in appearance and carry more silica, which seems to interfere with the calcination and also with the subsequent refining of the alumina.

The alumina residue, containing any silica present in the ore, is now discarded; but it is planned later to refine and use it. It has been discovered that the silica content may be reduced to less than one-half of one per cent by calcination with producer gas instead of pulverized coal and separation of the alumina from the silica by flotation. The average silica content of the ore used by Mr. Chappell's company is  $3\frac{1}{2}$  per cent. The loss on ignition is approximately 40 per cent, and the raw ore contains an average of approximately 10 per cent of  $\text{K}_2\text{O}$ , or  $18\frac{1}{2}$  per cent of  $\text{K}_2\text{SO}_4$ . The plant is operated profitably, and by reason of improvements and refinements which have gradually been developed, will, it is believed, be able to compete with Germany after the war.

### PINTADOS DEPOSIT IN CHILI

About sixty miles from the coast and directly on the railroad in northern Chili, is a deposit which while it cannot be correctly called a lake the result is essentially the same, and contains several hundred thousands of tons of workable potash in the form of a crystal body directly on the surface, averaging about 18 in. deep and covering many thousands of acres. The average analysis will show about 5 per cent of  $\text{K}_2\text{O}$ . This potash upon leaching and crystallization can be recovered as the muriate, or, if mixed with the raw material from which sodium nitrate is made and which immediately joins this deposit, can be recovered as the nitrate.

While this deposit is not in the United States, it is 1000 miles nearer to New York by water than California and is located where labor and other conditions are so favorable as to offset the high price of fuel. The climate is better than at some points in our western deserts and the country has a stable government. Revolutions are unknown and there has been less change in their constitution and general governmental methods during the past century than in the United States, England, France, or any other large country.

### GREAT SALT LAKE

This is a body of brine that has not gone nearly so far in the process of desiccation as Searles Lake. It has, however, for some time been looked upon as a possible source of potash. In fact, the Diamond Match Co. has had a plant in operation there for the past two or



three years, and has recently doubled its output. The Virginia Caroline Chemical Company in coöperation with the Inland Crystal Salt Company of Salt Lake City has also built a plant. However, the composition of the brine of the Lake is such that a very large amount of evaporation is necessary before the bitter liquors are sufficiently saturated with potash to make them workable. The primary evaporation is effected in open air, clay-lined ponds, during which considerable quantities of sodium chloride are thrown out. The bitter liquor remaining is then worked up for the separation of potash which is effected by evaporation, heating and cooling; and depends upon the varying relative solubilities of the different salts. The principle difficulty encountered is to bring about a satisfactory separation of magnesium chloride.

## Potash from Iron Ores and Fluxes

To the Editor of *Chemical & Metallurgical Engineering*

SIR:—Your editorial in regard to the recovery of by-product potash from blast furnaces is very timely. Only a few days ago I heard an expert connected with the War Industries Board express the view that the infant potash industry of this country may prove to be of an importance far above that represented by our immediate needs for potash, in connection with the negotiations for peace. The idea is that Germany will probably attempt to use her supposed monopoly of potash as a club to secure better terms, and certainly many utterances of her public men can be cited to bear out this theory. As it happens, there is in the August 1 number of the *Journal of Industrial & Engineering Chemistry*, page 665, a translation of an article from the *Deutsche Wirtschafts-Zeitung* of January 15, 1918, on "The German Potash Industry" in which the same idea is clearly expressed. In view of this probability, an established potash industry in this country might easily have a value not to be reckoned in dollars and cents if used to call the German bluff.

The recovery of potash in connection with the manufacture of Portland cement is going ahead very rapidly and largely because of the successful experience of the Security Cement & Lime Company. There are at the present time fourteen potash-recovery plants either in operation or in course of construction. Of these, eight are using or will use the Cottrell system, while six will use various other systems of collection.

The industry is still in its infancy and great advances in technical efficiency are possible. At Security we have already succeeded in increasing our percentage of potash volatilized (and thereby made available for collection) from about 40 to about 75 per cent. It is undoubtedly possible to carry this liberation even higher and it is also possible to greatly increase the efficiency of the collection apparatus. Even on the basis of the present state of the art, however, the cement industry is capable of furnishing approximately 100,000 tons of  $K_2O$  per annum or about one-third of the total requirements of the country.

Data do not exist for the calculation of the possibilities of the iron industry as a source of potash, but as you have pointed out, they are probably very great, and in some respects the proposition is more attractive than in the case of the cement industry. In the blast

furnace the volume of gases to be treated is much less per ton of material passing through the furnace than in the case of the cement kiln so that on the basis of equal potash content, the size of the investment in collecting apparatus would be less.

As I was at one time connected with the blast-furnace industry, I have been much interested in the possibilities of potash collection there ever since the success of our cement installation had been demonstrated. In coöperation with Mr. O. M. Stull of Buena Vista, Virginia, I have worked out a potash balance for one blast furnace and, so far as I know, these are the first data of the sort to be presented, with the exception of Wysor's excellent work published in the 1917 *Transactions of the A. I. M. E.*

|                             | Tons    | Lb.                                    | Per cent | $K_2O$ (Lb. of Total) | Per cent |
|-----------------------------|---------|----------------------------------------|----------|-----------------------|----------|
| Coke.....                   | 2,500   | $2,000 \times 0.384 \div 100 =$        | 10,333   | 39                    | 39       |
| Pyrites Cinder Nodules..... | 744.9   | $\times 2,240 \times 0.504 \div 100 =$ | 8,409    | 17.0                  | 17.0     |
| Manganese ore.....          | 159     | $\times 2,240 \times 0.895 \div 100 =$ | 8,192    | 16.4                  | 16.4     |
| Brown ore.....              | 1,581.7 | $\times 2,240 \times 0.227 \div 100 =$ | 8,062    | 16.4                  | 16.4     |
| Total ore.....              | 2,485.7 |                                        |          |                       |          |
| Dolomite.....               | 741.1   | $\times 2,240 \times 0.268 \div 100 =$ | 4,449    | 9.0                   | 9.0      |
| Limestone.....              | 741.1   | $\times 2,240 \times 0.350 \div 100 =$ | 5,810    | 11.8                  | 11.8     |
| Pig iron*.....              | 1,360   | $\times 2,240 \times 0.045 \div 100 =$ | 1,371    | 2.8                   | 2.8      |
| Slag.....                   | 1,444   | $\times 2,240 \times 0.500 \div 100 =$ | 16,172   | 32.9                  | 32.9     |
| Volatilized.....            |         |                                        | 17,543   | 35.7                  | 35.7     |
|                             |         |                                        | 31,639   | 64.3                  | 64.3     |

\*The percentage of potash found in the pig iron is so small as to raise the question whether it is not due to analytical error. However, the net result as to potash liberation is, in any event, only slightly affected.

This balance is based on a two-weeks' run, all materials except the slag being weighed and all analyses made in duplicate by a chemist experienced in potash determination. The weight of the slag was calculated. It will be noted that the percentage of potash volatilized from the furnace and which might, therefore, be recovered was 64.3 per cent of that entering the furnace, and amounted to 31,639 lb. in the two-weeks' period. As this furnace was working on a lean mixture with large slag volume and a fairly siliceous slag, it is probable that this figure represents somewhat less than the average liberation to be expected in blast-furnace practice.

These analyses show that the brown ores of Virginia are relatively low in potash; some published analyses in old reports of the U. S. Geological Survey show that this is also true of the majority of the Lake Superior ores. The Clinton red ores of the South are also low in potash.

The grey hematites of Eastern Alabama are probably the principal deposits of high-potash iron ores available in this country. The quantity of these ores has been estimated at 50,000,000 tons and upwards and the potash content ranges all the way from 1 to 3 per cent and over. It will probably average about 1.5 per cent. A little calculation will show that the possibilities for potash production from these ores are very attractive indeed. Aside from potash content, the analysis of the ore is very similar to the average brown ore of Alabama, and it has been used successfully at various times in blast furnaces in this district. An attempt is now being made to work out a project for the use of these ores involving the recovery of their potash content and it is to be hoped that it will meet with the success which it deserves.

JOHN J. PORTER.

Security Cement & Lime Co.,  
Hagerstown, Md.

# CHEMICAL & METALLURGICAL ENGINEERING

A consolidation of ELECTROCHEMICAL & METALLURGICAL INDUSTRY and IRON & STEEL MAGAZINE

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### The Exhibit of the Ceramic Section

TIME was when "Jena" and "Royal Berlin" were names to conjure with, and "Made in Berlin" was a sign of excellence which we now know can be achieved by other than Teuton ceramists. A visit to the ceramic section of the Exposition will convince one that the declaration of ceramic independence has been written for the United States, and that our brands of glass and porcelain ware are now free from the stigma of foreign antecedents.

The achievement constitutes one of the romances of the war. Prior to 1914 it was so easy to secure good laboratory glass and porcelain from Germany that nobody seriously considered domestic production. Schools and colleges got their supplies duty-free, and commercial organizations did not have to pay high prices. So thorough was our dependence that the industry had to be built from the bottom when war disturbed our customary imports.

Of course the country was not without potters and potteries, but their direct experience with laboratory porcelain was not extensive. Also we had glass works, but our brands of laboratory glassware had been regarded as inferior. The abstract of the census of manufactures for 1914 makes no mention of laboratory porcelain; nor does chemical glassware achieve the distinction that is given to nest eggs.

The problem was not too difficult for American manufacturers, however, and to-day's result is laboratory ware of excellence. This issue of CHEMICAL & METALLURGICAL ENGINEERING is a complete story of American ceramic independence. The various authors emphasize the possibilities of American raw materials and demonstrate the satisfaction rendered by the finished products. Their remarks should arouse a feeling of pride in every American chemist.

### American Clays and Ceramics

THE clay products industry is perhaps the most ancient and honorable of the chemical allies. Vases and urns of a considerable degree of fineness are constantly being found in the burial mounds of the prehistoric inhabitants of our hemisphere. The art appears to have originated in Asia and the fact that the aborigines of America knew it well indicates that there is some kinship between the Indians of Columbus and the oriental peoples. Upon the landing of the colonists in America, ship traffic was such that bricks and other clay products offered the most convenient form of return ballast, so that buildings along our coast from

Portland to Galveston were built of English brick. However, as our pioneers penetrated farther and farther into the forest, imported bricks became a burden, and with the pottery of the Ohio Indians showing what could be done, it was only natural that the ceramic industry should eventually be started. However, the colonial potter had been schooled to European methods and recipes, so that while he freed us of imported bricks, he subjugated us to foreign clays wherever the product would stand the freight.

With the recent interruption in ocean traffic and German imports, a much needed punch has been put into our ceramic industries. Foreign clays and clay products were stopped with a bump. The wheels of the industries began to turn faster than ever before. Ceramists had to get busy and contribute their share. How admirably the requirements have been met are exemplified at the Fourth National Exposition of Chemical Industries. From bricks to aeroplane engine spark plugs is a long trip, but the journey has been made at a finish pace that will break the world's records for speed.

The one great need for the acquisition of perfection in ceramics is the proper understanding of the science involved in the art. Chemical and physical properties cannot be studied independently. The requirements of the scientists in this field are so great and the technology so rich, that the American Ceramic Society is going to issue a journal. That greater progress is to be expected by this infusion of modern science into ancient ceramics goes without question from the results of the short period just past. American chemical porcelain ware will go down into the history of our industries with honors.

## Economics in the Works

**S**OME time ago we were called upon to examine into a long established industry. We were expected to admire, but we found nothing to praise. The leaders were men of eminence, many of whom had made comfortable fortunes while some had achieved great wealth. Wages were high even in normal times, and we were expected to show amazement and wonder and delight at the city's pride. But we did not. There was neither coöperation nor coördination nor research to be observed. There were wastes that might have been decreased at nearly every turn and there were opportunities to reduce the time factor in many processes, but the owners had no apparent interest in discovering them. Whether they believed in research or not they certainly did not encourage it. They were willing to let some other fellow pay for experiments.

We are trying very hard to do our share in the development of chemical statistics, but statistics require records, and the unprogressive manufacturer is conservative and declares that he is unwilling to publish his business secrets. In most cases he would be ashamed to have them known. From the census we can gather the production of raw materials and the gross products manufactured from them, but these estimated yields are incomplete and they constitute at best but *ex post facto* information. We can only compute the economic standing of an industrial establishment when we con-

sider the theoretical yields and compare them with its actual achievements.

It may not be profitable to publish such figures, but it is remarkably unprofitable not to know them. And yet how many manufacturers today know the relation of the performance of their works to the theoretical yields? We venture the opinion that the percentage is small, although this information is a proper accompaniment to cost-accounting, because it serves as a constant check upon neglect. Too often we have known manufacturers, who through ignorance and neglect were unable to attain the same yields as the more enlightened foreign competitors, to appeal to Congress for tariff duties to protect them against their own shortcomings. We venture the opinion that no manufacturer should have standing before the Tariff Commission who is unwilling to confess his yields.

If the waste is known to be excessive, where is it? How much of it is unnecessary? If it is in the materials, in which one is the fault, and what is the fault? How may it be corrected? Again, if the laboratory control is fair and the loss is unwarranted by good practice, the chances are that there is defect in supervision, because the workmen are not adequately trained. But that again is usually less the fault of the laborer than it is of the master, whose business it is to educate his men rather than to instruct them.

A man who is educated to perform his work knows the reason for every act. He becomes the master of the materials entrusted to his charge, and he knows what to do. If he is a good man he will want to learn, and he is less likely to make mistakes. The one who is instructed merely knows, for instance, that he must turn a cock off or on when something happens, and that is all he ever does know. The same attention is not to be expected from him as from the man who knows why he should do it and just what is happening. It is very important that this kind of education proceed apace in this country. In Germany, before the war, it was easy enough to have a specialized chemist in technical charge of every process. The workmen were organized under pseudo-military discipline and the Herr Doktor would utter *das Kommando* which the men would obey.

We cannot afford to maintain so large a professional faculty for the same amount of work in America. We doubt also if many American employers could stand that number of German chemists in their establishments, and American chemists won't work for the price. Moreover, we know very well that American workmen would not endure the *Kommandos* of the German chemists. We must, therefore, to come out even, educate our workmen to do a good part of that which was done by the German *Betriebschemiker*. This takes time and patience and good-will.

Chemical manufacture in America requires therefore first of all, familiarity with and practice of research. It demands also constant study of actual as compared with theoretical yields. It needs more intensive study of processes and consequently a broader understanding of their nature by the technical director of American works than was needed by a man in the same position in Germany, because the American technical manager cannot have as many graduated assistants. And provision must be made for the intelligent education of the workmen. Mere instruction is not enough.



## Sidelights on the Exposition

Among the whirling and moving exhibits is that of the Raymond Impact Pulverizer Co. of Chicago which shows a full-sized automatic pulverizer and  $\frac{1}{2}$ -size mill, pulverizer and separator, all in operation. To carry conviction they separate hominy and cork-dust and the exhaust fan from their cork-dust pulverizer blows right into the exhibit without messing things up. Each piece of apparatus is provided with windows to show what is happening inside. That is a good plan, whenever it is possible.

\* \* \*

One of the chemical colonels who visited the exposition told of a cootie-killing device that has been proposed which does the work by means of high-frequency currents. Tests that have been made thus far prove very favorable. One difficulty which the authorities met in their preliminary work was to have the desired number of cooties in one place for the necessary animal experimentation and to avoid, at the same time, any untoward distribution of them. The situation has been met by a good and patriotic man, too advanced in years for the draft, who is doing his bit by providing his own and proper person as host for the lively *pediculi*. These are herded, if we may use the term, within rings which are plastered upon the body of the pioneer in specialized patriotism and covered over to provide a safe enclosure. Within the enclosure and also underneath the cover there is laid a small piece of felt to allow the mother birds to lay their eggs under conditions which approximate, as nearly as possible, her normal home, but without the usual accompaniment of freedom. Whether the eggs endure the lightning flashes which follow in the interest of research we do not know, but parents as well as bachelors and spinsters (if there be any) and the growing youth of the species are said to succumb immediately.

We hope the anti-vivisection societies will not feel a call to protect the lives of these animals. Indeed, we fear their genial host might refuse to function if the vigorous old ladies who champion the cause of man's fellow beings of the animal world, were to insist that to the host's guests there be given life, liberty and the privilege to pursue happiness. St. Francis of Assisi is said to have referred to cooties as "Little Pearls of Righteousness," put in view of the fact that modern churchmen hold to the relative rather than the specific value of tradition, we are of the opinion that this animal experimentation may be carried on without sin.

\* \* \*

Among the exhibits that attract a crowd by the display of things in motion is that of an automatic sprinkler device for extinguishing fires. Owing to an excess of zeal, however, many of those who stop to look and listen are driven away again. The good people overbid the market, as it were. A large glass chamber is provided which is water-tight and at the top of which is fixed a sprinkler-head. For realistic demonstration of what happens in case of fire an automatic alarm bell is adjusted in the usual manner to the riser so that when a sprinkler begins to operate the alarm is sounded. At intervals, therefore, there comes forth from this gong an infernal, nerve-racking din which

is designed to induce any man who enjoys the use of his ears to jump into his clothes. The customary police rules against nakedness prevail at the Palace so that everybody present is clothed. The whang of this fire-gong therefore very nearly, but fortunately not quite, makes everybody jump out of his clothes and take to the windows. To the optimistic temperament there is always occasion for thanks. We rejoice that our booth is not adjoining.

\* \* \*

The Newport Chemical Works, Inc., of Milwaukee, show phenol, of course, for they make not less than 125 tons a day of it, we are informed. They have also an impressive list of coal-tar intermediates of which the following bear the bull's-eye mark: Dinitro-oxydiphenylamine, ortho anisidine, chromotropic acid, alphanaphthylamine and dianisidine. Guaiacol, c.p. in crystals and liquid is offered for pharmaceutical purposes. Then, firmly insisting that Milwaukee is on the map of the United States and probably also because they have a considerable number of intermediates full handy, they have gone into dyes and display a couple of dozen direct, acid and sulphur colors.

\* \* \*

At the exhibition of the Swenson Evaporator Company we were informed that they have just completed a caustic-soda reclaiming outfit for the U. S. Government Explosives Plant C at Nitro, W. Va., of very large capacity. It includes evaporators, disc evaporators, incinerators, leaching battery and other apparatus which required over 30 car-loads for shipment.

\* \* \*

Major Leo F. Goodwin, formerly of the College of the City of New York but now of Canada, was pretty well smashed up by the Huns, but he is still in the ring. As he sat in the booth of CHEMICAL & METALLURGICAL ENGINEERING yesterday, reading our daily issue he suddenly pointed to a line, looked up and asked "Who wrote that?" The line he indicated was that in which we offered free and clear, with no patent rights claimed, the suggestion that tellurium dyes might be made to take the place of sulphur colors. The guilty man was present and acknowledged his invention. "Have you ever worked with tellurium compounds?" asked the major. The guilty man admitted that he hadn't. "Well, you never would have put that idea into the minds of aspiring young chemists if you had!" he continued. Then he related from his own bitter experience something of the habits of tellurium, when it starts out in chemical society and begins to make combinations. It displays, he declared, an odoriferous character that reminded him of garlic that had committed suicide. It seems as agreeable and as strong as the mercaptans, and even more enduring. He imagined a beautiful, golden-haired child all arrayed in a pretty new tellurium-blue dress, obviously by a mother with atrophied olfactory organs. And the major, who is fond of children, could imagine no other course of action for the distressed father to pursue than to throw the child out of the window upon the rubbish heap and to make a dash for the North Pole.

Poor tellurium is evidently without friends. We lately reported the indifference of the copper refiners to

it and now comes this learned professor who displays a distinct antagonism.

\* \* \*

The E. I. duPont de Nemours Company shows a great variety of things. Among the novelties is a new rough pyroxyline finish called "crystalac" that may be applied to any hard surface. It is very effective and handsome on glass. They have entered the field in making bronze powder which is displayed in various stages of manufacture. Another thing is dip-colors for electric lights which are applied to finished incandescent bulbs. Artificial limbs are exhibited, made of *papier mache* with a pyroxyline finish. The samples are pink or flesh color, but we have no doubt but that they could easily produce a whole series of chocolate and horse-chestnut hues to meet even the approbation of the art critic of the *Chicago Defender*. Last year they gave away samples of a household cement which this year is going strong without the need of free samples. Under the trade name of "pontoklene" they show a preparation to remove road-tar from automobiles. In the fabrikoid department they have coming along and ready to introduce, but not yet shown, a kind of hospital sheeting that is an improvement on rubber sheets. From the Harrison Works they have of course a great line of paints, and at the dyestuff end are shown about fifty intermediates and some twenty-five direct, basic, acid, chrome and sulphur dyes. This company is engaged in the manufacture of so many different kinds of chemical products that any discussion of the scope of their activities sounds like a poem by Walt Whitman.

\* \* \*

The coal-tar tree is shown in many manifestations. The National Aniline & Chemical Co. has a large number of bottles arranged in the form of a pyramid with tar at the apex; on the shelf below are the crudes and on the two shelves below this is a comprehensive array of complicated intermediates. Dr. Derrick, the head of the National company's great research laboratory at Buffalo was present as we passed by and we congratulated him on his vast progeny of research. "It was co-operation that made them possible," he replied, "and believe me, some of them were hard to bring up. In fact, some of them were as full of tricks as the wildest boy that ever wanted to shoot Indians."

The National Company conceives the bull's-eye to show that the products have been made in America and by them for the first time from all American materials. They have 169 subjects so marked and very few of them have been made by anybody else in this country before out of German or any other kind of intermediates. Another feature of their show is that nothing is displayed which the company cannot deliver. Some products which are very much desired are on hand in appreciable quantity but they will neither be shown or offered until regular production is established in the works. We were glad to observe one sample of dye and colored yarn of the indanthrene type. That is a good sign. We have been whistling for these colors for a long time.

\* \* \*

The sign of the bull's-eye, which means made in America for the first time since the war began, is

differently construed. Some exhibitors hold it to indicate articles made for the first time with all American materials while others construe it to mean that articles so designated have never been made in this country before without reference to the origins of materials. Others again seem to hold that anything which they themselves make and now show as their own product for the first time is entitled to a bull's-eye. And others, having distinct novelties, do not attach it at all. The sign would have more value if there had been made a clearer definition of its purpose; however, bull's-eyes have always been hard to hit at the first shot.

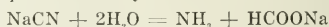
\* \* \*

A guest at the expositiion who is in a quandary how to produce certain materials fast enough to meet his contracts owing to the labor shortage, said that he would know exactly what to do with 40,000 Turks, which is a question said to be bothering General Allenby at the present time.

\* \* \*

Sometimes we think we know what is going on if we read the journals and the advertisements and go to the meetings of the chemical societies and visit the Chemists' Club, but we make no pretensions to the eagle eye that sees everything. For instance, there's Mr. Floyd J. Metzger who was associate professor of industrial chemistry at Columbia University until a year ago last February. He gave up academic distinction to engage in work for the Air Reduction Co.—the Claude process people who make liquid air and sell oxygen; it is a large concern as everybody knows. It stands to reason that they must have some nitrogen on their hands; lots of nitrogen.

Right there is where Mr. Metzger has been at work and at the Exposition the Air Reduction Co. has a single booth on the third floor. They show a considerable array of synthetic sodium cyanide, made of that boiled nitrogen, and we are told that the technology has been brought up to the theory:



This reaction has been somewhat of a teaser for a long time, but we are assured that the theoretical yields of ammonia and sodium formate are achieved. Now in addition to the cyanide and formate of sodium there are displayed the following products of their New Jersey works: formic acid and seven formic esters, up to amyl formate; sodium ferrocyanide; aqua ammonia and sulphate, chloride, nitrate and carbonate of ammonium together with *Paris* and Turnbull's blues. The name *Paris* is given to this otherwise Prussian blue on the ground that, being a synthetic product it lacks the usual livers and lights and consequently deserves a better name. The works are still small but are operating at maximum capacity.

We confess that we feel like apologizing. With nitrogen fixation going on, right across the table, so to speak, and we missing it, we feel we need some of Col. Sellers' Celebrated Eye Wash to quicken our sight. It makes us feel like the boy who went to the Sunday School entertainment and missed the circus. If Mr. Metzger were one of those silent fellows that keeps off in a corner by himself we should not take it so to heart, but he isn't; he is a good mixer.

## Recent Developments in Ceramics\*

### Increased Demand for Silica Brick—Replacement of German Clays—Development of Porcelain and Chemical Stoneware Industries—Success in Optical Glass Manufacture

By A. V. BLEININGER

ONE of the most important functions of the ceramic industries is the supply of refractories for the metallurgical operations of the country, steam power-plants, byproduct coke oven, gas plants, glass works, and many other purposes too numerous to enumerate here. The demand for these products has been enormous and has been met by the refractories industries in a very satisfactory manner. Although at times the need of No. 1 fire-bricks has been greater than the production, such a condition does not exist at the present time, owing to the expansion of this branch of the industry. In many instances the extraordinary demand was caused in part by the unwillingness of consumers to use anything but No. 1 refractories even for purposes where lower-grade products would serve equally well. Fire-bricks of the lower refractory grades are available in abundance, especially since a considerable number of face and building-brick plants have taken up the production of this type of ware. One of the urgent needs in this connection is the establishment of a classification and specification of the several grades of clay refractories. This task is being undertaken at the present time by the War Industries Board. The work of standardizing the shapes of fire-brick has already been accomplished in a satisfactory manner.

#### COKE OVENS INCREASE DEMAND FOR SILICA BRICK

The demand for silica bricks has been greatly increased through the development of the byproduct coke oven. Meeting this demand involves not only large quantity production of these refractories, but high quality as well. It is necessary that the transformation of the quartz to cristobalite be largely completed as indicated by the lowering of the specific gravity to a value of not more than 2.38 and that the product possess good mechanical strength, corresponding to an average modulus of rupture of about 500 pounds per square inch. These requirements are exacting and may not always be met in bricks made from silica rock other than quartzite. Certain materials, like chert and flint, transform to cristobalite more rapidly than quartzite but do not yield as strong a product. Sandstones usually transform more slowly and likewise tend to give inferior strength.

The manufacture of silica refractories is certain to expand still more, both in the eastern states and in the middle west. If the war continues for any considerable period, additional emergency production in connection with the erection of new coke-oven plants will certainly be necessary.

Difficulties have been met in supplying the basic magnesite refractories from the available American

materials. This has been due to the nature of our magnesite, which differs from the Austrian ore in being very low in iron oxide and sometimes higher in lime. This makes it necessary to add the iron synthetically, a procedure which adds to the cost of production, since it requires intimate blending and grinding of the mixture and a higher calcination temperature than is needed with the European raw material. In addition the magnesite must be transported across the continent from California or Washington. The latter state produces at the present time large quantities of magnesite quite low in lime and the quality of the material is of a character which is making it possible to reduce operations to a uniform practice.

It has been found possible also to replace magnesite bricks in certain operations by bauxite refractories. The production of magnesia spinal refractories of the composition  $MgO \cdot Al_2O_3$  has made a beginning and it is not unlikely that for many purposes it will prove a very desirable material. There has naturally been a shortage of chromite refractories, even though the quantities really needed are small. This has been overcome by the use of thinner partings and in many cases by doing away with this refractory entirely without apparently any serious effects.

#### SUPERIORITY OF CEYLON GRAPHITE

Much has been said on the question of graphite crucibles. The graphite problem is undoubtedly the more important one in this connection. It is a difficult matter to replace Ceylon graphite altogether with the domestic mineral. In the first place the greater density of the imported material, 2.25, which imparts to it the characteristic resistance to oxidation, its foliated structure, and the low ash content of the best grades combine to make it extremely satisfactory for the purpose of crucible making. This graphite can be bonded together with a comparatively small amount of clay, since the surface factor per unit weight is smaller than for that of any other kind of graphite.

This point may be illustrated by the volumes occupied by the same weight of several types of graphite. Thus, 100 grams of ground Ceylon graphite after thorough shaking occupies a volume of 90.7 c.c., Canadian graphite 119.6 c.c., and Alabama graphite 152.0 c.c. In other words, it would be impossible to make graphite mixtures of maximum carbon content from the two American materials. Since they offer a much larger surface the amount of clay used must be greater. From this it follows that the ultimate density and thermal conductivity are certain to be lower.

To what extent American flake graphite can be admixed with the Ceylon graphite remains to be seen. The writer has seen mixtures in which the flake added

\*By permission of the Director of the Bureau of Standards. Read at the meeting of the American Ceramic Society, New York, September 26, 1918.



amounted to 20 per cent of the total graphite content and gave fair foundry results. It might be possible, however, to perfect processes which will enable the crucible maker to employ larger percentages of domestic graphite, and at the same time secure practically the same results as with Ceylon graphite. On the other hand, there is no reason why a large quantity of domestic graphite should not be used in the making of stoppers and similar articles. The comparison made between the Ceylon and flake graphite is, of course, relative, and refers to crucible value obtained per dollar at the present time. If for some reason this country could no longer obtain Ceylon graphite, the production of metal certainly would not be diminished in any way, as we could get along very well with flake and amorphous graphite, furnace carbon, and coke.

#### GERMAN CLAYS SUCCESSFULLY REPLACED

The lack of the German Klingenberg clay for crucible making is not as serious a matter as has been thought. It has been shown conclusively that it can be replaced both by English and American ball clays.

Similarly, the German Gross Almerode clay used in the making of glass pots has been replaced by American clays and synthetic mixtures in a very satisfactory manner. In fact, it is quite probable that the new techniques now being developed will yield results superior to those formerly obtained with the use of imported clay. The shaking up caused by the war will, in the end, be of distinct service to the glass refractories industry. At the same time, the glass industry will gain in pot service through the realization that the control of the heating up process of the pots in the arches is essential in preventing loss.

Special clay refractories have been developed also with reference to improved thermal insulation, including materials highly refractory, light in weight, and possessed of good insulating qualities. The saving in fuel consumption and weight through the use of such products is bound to be considerable.

#### DEVELOPMENT OF PORCELAIN INDUSTRY A NATIONAL DUTY

The manufacture of hard-fire, true porcelain has received a powerful impetus through the war. Three plants are already operating successfully on the production of chemical porcelain, and are making rapid strides with respect to quality. The manufacture on a large scale of hard porcelain tableware is to be begun in the very near future. It is very fortunate that the pioneers in this work have realized the importance of putting their production on a firm basis with reference to foreign competition. By the use of automatic machinery, mechanical dryers and tunnel kilns, they will be enabled to meet foreign competitors on equal terms. The plants now in course of construction excel all European potteries in the elimination of unnecessary labor cost, and expenditure of fuel. The development of a hard-fire porcelain industry is, indeed, a national duty. It would be preposterous and humiliating to contemplate any further dependance on Germany and Austria for these products. By establishing this industry we shall be in position to seek the South American markets to which we have a fair right.

The demand for ordinary tableware at the present

time is greater than has ever been known before and difficulty is being experienced in supplying the requirements of the Army and Navy and at the same time those of the country. The simpler shapes such as cups and mugs are now being produced by the one-fire process, which incidentally results in an appreciable saving of fuel.

#### NEW PORCELAINS SHOW HIGH ELECTRICAL RESISTANCE

Porcelains for special purposes have been developed successfully. Thus, the national Bureau of Standards has introduced the manufacture of the refractory Marquardt porcelain, essentially sillimanite, formerly produced by the Royal Porcelain Manufactory at Berlin and used so largely for pyrometer tubes and similar articles. Likewise, we have succeeded in making porcelains possessing remarkably high electrical resistance at elevated temperatures. Several of the bodies produced in the Pittsburgh laboratory of the Bureau of Standards showed a resistance of one megohm per cubic centimeter at 780 deg. C. and at the same time a coefficient of thermal expansion of only  $3.81 \times 10.6$  per deg. C. between the temperature range of 30 to 400 deg. C.

The same materials showed none of the variations in thermal expansion common to most porcelains, the coefficient remaining practically constant throughout the range of 30 to 520 deg. C. It is evident that such properties, coupled with good mechanical strength, are essential for such uses as aeroplane spark plugs. There is every reason to believe that the principles thus worked out will greatly assist in producing special grades of electrical porcelain for use under severe conditions. These developments have been assisted greatly through the use of the petrographic microscope in the study of porcelain structures.

#### FURTHER DEVELOPMENTS IN PORCELAIN EXPECTED

The manufacture of electrical porcelain is undergoing improvements at a more rapid rate than ever before in the history of this particular industry. The methods of preparation are more thorough, the details of shaping are being studied more carefully, the drying process is being controlled with greater accuracy, and the methods of testing developed toward more exact differentiation as to quality. The casting process is finding application to an increasing extent. Further developments are to be expected with reference to the composition and firing of electrical porcelain, based on more recent studies on the subject of the function of feldspar as an electrolyte and the volume changes induced by the transformation of quartz to its several crystalline modifications.

Considerable work is being done also with regard to the complete survey of the resources of the country in kaolins and ball clays for use in the ceramic and paper industries, through the agencies of the Association of State Geologists, the Bureau of Mines, the U. S. Geological Survey, the American Ceramic Society, and the Bureau of Standards. It is believed that this survey will enable us to take stock of our resources with the final object of making ourselves independent of any foreign sources. A considerable number of new clay deposits have been located within the past two years, to

say nothing of glass, sand and other ceramic raw materials.

#### CHEMICAL STONEWARE INDUSTRY OF VITAL IMPORTANCE

One of the clay industries vital in the prosecution of the war is the manufacture of chemical stoneware. The production of this type of ware requires particular skill, owing to the complicated designs, large size and the necessity of the tight fitting of the pieces. But few realize the magnitude of the task which confronted this industry, especially when handicapped by shortage in labor, fuel and other necessities. It is very gratifying, indeed, to be able to say that the stoneware manufacturers have met the situation so well and have been able to supply the needs of the chemical industries. This statement applies equally to the manufacturers of acid-proof, enameled cast-iron and sheet-steel products which have played an important role in recent chemical developments.

Another industry having a direct bearing upon war work is that engaged in the manufacture of abrasives and grinding wheels. The rapid growth of this branch of manufacture and its technical development are characteristic of America. Its work has been done with such quiet efficiency and it has met the demands of the present conditions so promptly that but few realize the magnitude and importance of its accomplishments. Research has played a large part in this development and to the utilization of scientific facts we owe the highly specialized grinding tools made available for large production, as well as for the most delicate processes, such as the grinding of optical lenses.

The industries engaged in the production of ceramic structural materials have naturally been hard hit by the decrease in building activities and by the fuel orders. The manufacturers of building bricks, hollow tiles, sewer pipe, paving bricks, terra cotta, floor and wall tile etc. are endeavoring to hold together their organizations. In districts where war activity prevails the plants are operating to capacity; in others new branches of manufacture have been taken up, such as the production of refractories, crucibles, and certain specialties for war use. But even under such conditions interesting developments are taking place. Much attention is being given to the question of fuel economy through more rapid firing and the utilization of waste heat. New applications of clay are being found such as the use of crushed vesicular vitrified brick material as an aggregate for concrete, having the advantage of light weight, low thermal conductivity, and constancy of volume when heated.

#### OPTICAL, SIGNAL AND CHEMICAL GLASSWARE

With reference to the glass industry the three most interesting developments are those relating to the optical, colored (signal), and the resistant or chemical glasses. When it is realized that at the beginning of the war but little optical glass was being produced in the United States, the rapid development of the art presents an inspiring example. The necessity of war brought together the manufacturers on the one hand and scientific and technical organizations like the Geophysical Laboratory of the Carnegie Institute and the Bureau of Standards on the other.

Although some of the manufacturers had brought their furnace practice to a very satisfactory state it was not realized fully that the raw materials must be practically free from iron, sulphur, chlorine, and other impurities. Likewise, methods for the rapid examination of the glass were lacking so the frequently poor glass was brought to the grinding and polishing rooms of the optical shops; very often, too, good product was by chance rejected. The necessity of temperature measurement and control was not fully realized and the method of stirring had not been brought to a satisfactory development. At the same time the commercial glass pots were the source of much grief due to their high iron content, which discolored the glass in the absence of decolorizers which are not allowable and their failure to resist the corrosive action of the flint and barium glasses. These things have been overcome to a very large extent.

#### RAPID PROGRESS IN PRODUCING GOOD GLASS

Through the use of sand of great purity and constant checking of the composition of the other constituents, the primary difficulties have been removed. The composition of the glasses has been correlated with the optical properties, the index of refraction, the dispersion value, and the light absorption. Time-temperature schedules have been worked out for the melting and cooling periods and satisfactory stirring machines designed. Rapid inspection even of the glass in lump form is now possible by the use of immersion methods and examination with mono-chromatic light in addition to the examination through the polished edges of blocks.

The pot problem has been solved through the use of white burning clays like the kaolins and even more satisfactorily by the production of semi or true porcelain pots. Containers of the latter type are now being made in several works and have proved eminently useful. In fact, it has been possible to melt in such pots dense barium crown glasses which have proved exceedingly destructive to the ordinary types of refractory materials.

#### ESSENTIALS OF OPTICAL GLASS MANUFACTURE MASTERED

The annealing process is being studied by a number of workers, and some interesting information has already been obtained. It might be said then that in the United States we have mastered the essentials of the production of optical glass, and about seven types are being manufactured commercially. Problems dealing with the cutting down of the losses of certain optical phenomena etc., of course, still remain; it is to be expected that continued progress will be made in this art.

It is a source of pleasure to note also the fact that scientific and technical researches dealing with the technology of silicates are being continued at the present time, even though they have more or less bearing upon conditions brought about by the war. We are mastering more and more the control of the class of dispersed systems represented by clays floated in water, their drying behavior, and the changes which they undergo upon vitrification and fusion by resorting to the methods of the scientific investigator.

In this brief survey it has not been possible to empha-

size some of the more important technical advances, nor was it permissible at this time to dwell upon certain developments, such as a new rôle played by clay in chemistry, but it is hoped that this hasty contribution might afford some conception as to the activities in the ceramic industries.

Pittsburgh Laboratory,  
Bureau of Standards.

## Chemical Glassware

By E. C. SULLIVAN

MORE chemical glassware is made in this country to-day than was imported before the outbreak of the war, when we depended upon foreign makers for practically our entire supply. The quality is excellent. The Bureau of Standards reports that all of the five brands of American-made beakers and flasks which it tested are equal or superior to the highest grade foreign glass and that one American glass is far superior in the important property of resistance to mechanical shock.

From Table I compiled from the Bureau of Standards report,<sup>1</sup> it is apparent that on an average four of the five brands of American flasks and three of the five brands of American beakers were less soluble than the German in the nine reagents used.

TABLE I—COMPARISON OF FOREIGN AND DOMESTIC GLASSES

|              | H <sub>2</sub> O | NH <sub>3</sub> | (NH <sub>4</sub> ) <sub>2</sub> S<br>& NH <sub>4</sub> Cl | Acids | Na <sub>2</sub> HPO <sub>4</sub> | Na <sub>2</sub> CO <sub>3</sub> | K <sub>2</sub> CO <sub>3</sub> | NaOH | KOH | Total |
|--------------|------------------|-----------------|-----------------------------------------------------------|-------|----------------------------------|---------------------------------|--------------------------------|------|-----|-------|
| Beakers..... | 4                | 4               | 2                                                         | 5     | 5                                | 3                               | 3                              | 5    | 4   | 23    |
| Flasks.....  | 4                | 4               | 5                                                         | 5     | 4                                | 3                               | 2                              | 5    | 3   | 35    |

(The figures indicate the number of brands of American glassware found to be less dissolved in the respective reagents than the brand of imported ware formerly regarded as the best on the market.)

### SUPERIORITY OF AMERICAN BEAKERS

The American beaker shows superiority over the foreign in twenty-five cases and equality in four cases (one with water, two with ammonia, one with acid) while the American flask is superior in thirty-five cases and equal in one case (with caustic potash). This difference between the comparative showing of the beaker and that of the flask is almost too great to be accidental and seems to indicate that the foreign flask is more soluble than the foreign beaker.

Another class of laboratory ware, in which resistance to sudden temperature change and to attack of reagents is of less importance and which includes such shapes as desiccators, cylinders, bell-jars etc. has been of slower development in this country but these articles are now being made here in reasonably satisfactory quantity and quality.

Suitable tubing for working before the lamp in the manufacture of such apparatus as cannot be blown or pressed directly in the glass-factory is now produced also, and gratifying progress has been made in the organization of lamp-working<sup>2</sup> establishments for thus manipulating the tubing into the more complicated shapes.

<sup>1</sup>Technologic Paper of the Bureau of Standards, No. 107, "Comparative Tests of Chemical Glassware," by Percy H. Walker and F. W. Smith (1918).

<sup>2</sup>In the glass trade the "glass-blower" works molten glass from the melting-pot or tank, blowing it into bottles, beakers, tubing, etc.; as a rule he knows nothing of the fabrication of apparatus from tubing in the flame, which is the function of the "lamp-worker."

### SPECIAL GLASS FOR ARMY MEDICAL DEPARTMENT

Referring more specifically to what has been accomplished in chemical glassware since this country entered the war, in the first line would come probably glassware furnished the U. S. Army Medical Department for bacteriological purposes. This glass, which is reported to be of quality far ahead of any ever imported, was absolutely essential in the immunization of the troops against typhoid fever, an immunization the results of which have been record-breaking and for which the U. S. Army Medical Department cannot be given too high credit. Very large quantities of high-grade chemical glass of special shapes have been supplied to ammunition manufacturers also.

In view of the fact that the highest priced American-made beakers and flasks are selling at practically the duty-paid pre-war price of the highest grade imported ware, although the latter has since been advanced in price twice, it may be of interest to consider for a moment in the light of tariff protection the circumstances which led to the establishment of the chemical glassware industry in this country.

At a Tariff Commission hearing on glass held in Pittsburgh in January, 1918, Commissioner W. S. Cudertson remarked, "This case of chemical glassware is an excellent example of a war disturbance. Here is an industry not in existence in this country before the war; the war has raised an artificial barrier against competition from abroad and we have growing up in this country a new industry."

### REASONS FOR ENTERING THE FIELD

The factors which had weight in determining American manufacturers finally to enter a field from which they had hitherto held aloof were as follows:

1. Sentiment. Undoubtedly patriotic motives and the strong appeal made by chemists and supply houses to glassmakers for relief from the threatening shortage were of some influence.
2. Higher returns. The fact that without foreign competition the full duty-paid price could be asked on all sales, to educational institutions as well as to others.
3. Assured market. There was no slow ousting of the foreign competitor from his established position to face, as would have been the case had the American goods been protected only, for instance, by an extension of the duty to include importations for educational institutions.

If No. 2 was the determining factor it follows that duty-free importation by educational institutions has prevented earlier development of this industry in America. If duty-free importations are 50 per cent of the total and if the tariff is 45 per cent *ad valorem*, then for every dollar saved to the educational institutions about \$4.50 of American money has been paid the foreign glass manufacturer which, with a domestic industry developed, would have remained here.

On the other hand, if, as is more likely, No. 3 was the factor of most influence, it follows that a prohibitive barrier, such as interruption of commerce or a very high tariff, may be effective in enabling an industry to get a foothold without causing any increase in price to the consumer.

Corning Glass Works,  
Corning, N. Y.



# Recent Developments in the Cement Industry

## Conversion of a Peace Industry to the Purposes of War—Economies Effected in Fuel and Labor, and Recovery of Potash

By RICHARD K. MEADE

THE cement industry can hardly be said to have profited by the war, although the price of its product is very much higher now than it was several years ago. This increase in price, however, has been met to a large extent by the present high wages paid labor and the cost of fuel and supplies. During the last year, also, the production of cement has been very much curtailed, due to the difficulty of procuring the men, fuel and repair parts necessary to operate the plants at anything like their full capacity.

The cement industry is essentially a peace industry. Its product goes largely to the building trades, for the making of roads and pavements, in municipal improvements, in the development of water powers etc., all of which work has very largely stopped during the past year. As with the metal industries, the output of the mills is now going largely into work of national importance which is approved by the War Industries Board, probably 90 per cent. of the cement shipped today being destined for such use.

The construction work engendered by the war is not of a type in which large quantities of cement are used. The temporary character of the greater portion of this has made the use of concrete unnecessary and the speed with which construction must be pushed has made other building materials more acceptable.

There have been few compensating features to this situation. Both the technical and popular press has given much space to the concrete ship. While most concrete engineers are firm believers in the importance of this type of vessel for emergency purposes, its successful development would not mean any large increase in the use of cement. Any one of several large producers of cement could, by working his plant at full capacity, produce cement enough in one year to duplicate the entire present ship tonnage of the allied nations; and almost any works could produce enough cement in one day's time to build a ship of the size of the "Faith," the first large concrete ship.

### FUEL AND LABOR LARGEST ITEMS IN COST

In probably none of the great non-metallic industries does fuel play such an important part as in the manufacture of cement. In normal times, the cement mills of the country use between 8,000,000 and 10,000,000 tons of coal; or almost half as much coal is brought into the plant as there is cement carried out of it. The high price of coal and the difficulty of obtaining this have, therefore, been felt very keenly in the cement industry.

The largest item in the manufacture of cement, in spite of the automatic handling of the materials at all stages of the process, is labor. Under ordinary condi-

tions these two items, fuel and labor, make up 80 per cent. of the cost of manufacturing a barrel of cement. The value of the raw materials plays very little part in the cost of manufactures as these consist principally of limestone and shale or clay, which are usually obtained by quarrying from practically inexhaustible sources at the plant itself. Transportation difficulties have also fallen heavily on the cement manufacturer as even a small mill requires from 15 to 20 box cars per day to carry its product away.

### ECONOMIES IN FUEL, LABOR AND POTASH

So much for the business side of the industry. The principal technical developments have been along the line of saving labor and the recovery of potash and heat from the waste gases of the rotary kilns. Improvements, however, owing to the high cost and difficulty of doing construction work, have been confined to only a few plants, and with the vast majority of works the war has made no difference except, as in all other industries, in rendering operation extremely difficult.

Viewed from the chemical standpoint, the most interesting occurrence has been the collection of potash from the waste gases of the rotary kiln. As far back as 1904, the writer, at a meeting of the Association of American Portland Cement Manufacturers, called attention to the fact that approximately half of the potash in the raw materials was volatilized in burning the cement and that the crust which collects on the walls of the kiln stack and has to be removed at intervals contains a considerable percentage of potassium sulphate. No attempts were made to recover the potash from the kiln gases prior to the war, however, and owing to its low percentage of potash I believe that none of the crust was sold for this constituent.

### SOLVING THE DUST NUISANCE

There has always been objection raised by some of those living near cement mills to the fine dust which is carried out of the kiln stacks and which deposits in the vicinity. While it is extremely doubtful if this dust does any harm to vegetation and certainly is not injurious to health, at the same time it has proved a bone of contention between the cement works and its neighbors. In Southern California particularly, suits brought by the orange growers against the cement plants resulted in injunctions restraining the cement plants from operating without taking care of the dust. The two plants in Southern California, the Riverside Portland Cement Co. at Riverside, and the California Portland Cement Co. at Colton, immediately installed dust-collecting systems. Dr. Cottrell had just worked

out his electrical precipitation method and this was installed at the Riverside plant. The California Portland Cement Co. installed a system of large dry settling chambers followed by washing chambers for treating their gases which was devised by their manager, Mr. T. J. Fleming.

It was soon noticed that the dust recovered by the Cottrell process contained an appreciable amount of

to his directors that they install the apparatus, which they did. This plant has been unusually successful and has been collecting daily from 20 to 25 tons of dust containing from 8 to 15 per cent water-soluble potash, which is sold directly to the fertilizer manufacturers.

When the apparatus was put in operation here, a peculiar thing was noticed, that whereas at Riverside practically all of the potash present in the dust was

water-soluble, at Security a considerable portion was not water-soluble. The explanation for this is that at Riverside the kilns are heated with oil while at Security pulverized coal is used, and it is believed that in some manner the potash recombines with the coal ash to form a silicate. This silicate of potash, however, can be dissolved with dilute acid or it can be made soluble by leaching the dust with water under pressure in an autoclave.

By adding salt to the raw materials, the volatilization of potash from these can be very materially increased. Messrs. Huber and Reath recommend and have patented the use of

calcium fluoride for a similar purpose. It was also discovered at Security that by the use of salt the recombination of the potash with the coal ash could be lessened to a considerable extent. It has been found, however, that where salt or calcium fluoride is employed the efficiency of the treater is decreased, and that while the volatilization is increased there is a proportionately larger quantity of potash not caught by the treater. In order to collect the potash so lost, a supplementary water-film electrical treater has been developed at the Security plant through which the gases are passed after leaving the dry treater. This is now said to be working satisfactorily.

The Cottrell dry treater, as most chemists know, consists of a large number of sheet-iron tubes through the center of which wires are suspended. These two form the electrodes, the gases passing up through the tube, the dust being deposited on the surface. In the water-film treater, the wires are employed but are located between two walls of concrete over the surfaces of which a thin sheet of water is allowed to flow and between which the gases pass. This film of water is a conductor of electricity and acts as does the surface of the tube in the pipe treater. The discharge between the wire and the water-film carries the potash to the latter where the water dissolves it. The same water is circulated over and over again, the solid matter being allowed to settle out; the solution thus gradually builds up in potash. When of the desired concentration it is drawn off, any solids left in suspension are filtered off, the liquor is evaporated, and the potash salts obtained by crystallization.

We have mentioned the precipitation of the dust at the plant of the California Portland Cement Co. by the use of dry settling chambers followed by water

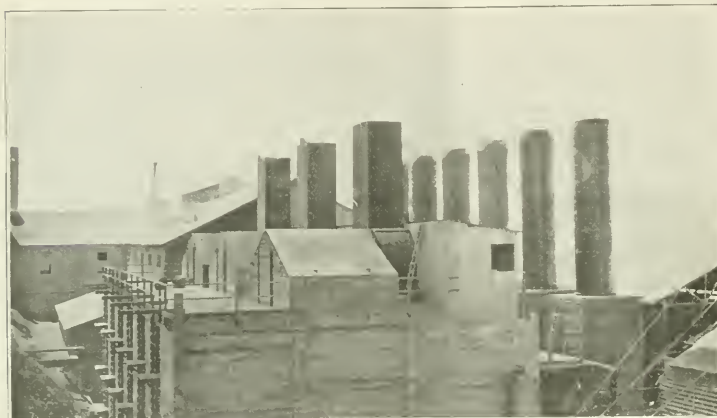


FIG. 1.—POTASH-RECOVERY PLANT, SANTA CRUZ PORTLAND CEMENT CO.  
(FANS NOT RUNNING)

potash. No serious attempts were made, however, to sell this dust until the outbreak of the war, when it became a marketable product.

A little later on, Messrs. Huber and Reath, chemists of the Riverside Portland Cement Co., developed a process for extracting potash salts from this dust. The process is quite fully described in *METALLURGICAL & CHEMICAL ENGINEERING* of June 15, 1917, and consists briefly in leaching the dust with hot water, separating the solution from the insoluble matter by means of a rotary filter, evaporating the filtrate to the point of saturation and crystallizing the potash out of this in shallow tanks. The product obtained runs from 35 to 40 per cent potash and consists very largely of potassium and sodium sulphate with some sulphur in a lower state of oxidation.

With the outbreak of the war, the crust which collects inside of the kiln stacks became valuable and large quantities of this have been sold by the cement manufacturers in the past three years. The dust runs between 8 and 12 per cent potash. The quantity of the potash so recovered, however, is very small when compared with the total potash liberated in the kiln.

#### FIRST PLANT PRIMARILY FOR POTASH RECOVERY

The first Portland cement company actually to install apparatus with a view to collecting potash was the Security Cement & Lime Co., Security, Md. Mr. J. J. Porter, manager of this company, was a visitor at the National Exposition of Chemical Industry in the fall of 1915. While there he saw the Cottrell process in operation in a small way and was impressed with the possibilities of collecting potash by this process. He made a trip to the Riverside plant, saw the apparatus there at work, came home and recommended

sprays. It was quite natural that the attention of this company should also have been attracted to the possibility of obtaining potash, and a process for such recovery has been worked out by Mr. W. C. Hanna, chief chemist of this company.

#### WET SYSTEMS OF RECOVERY

In this system, too, the water circulates through the spray system over and over again and gradually gets stronger and stronger in potash. When of the desired strength, a certain portion of this liquor is pumped over into a tank where it is used to leach the dust which collects in the dry chamber. The dust is then separated from the solution by means of an Oliver filter. The former is returned to the kiln and the potash solution is evaporated in open pans. These are located on top of the flue leading the hot gases from the kilns to the treater, all of the heat necessary being furnished by the waste gases. As this flue slopes, each pan is set somewhat lower than the preceding one and the liquor to be evaporated flows from the top pan down through the whole series. The potash is shoveled out of the lower pan and is either dried on the casing of one of the fans and placed in sacks for shipment or else sent to storage in the damp state. This plant is now producing between 3000 and 4000 pounds of potash salts per day, containing approximately 40 per cent potash.

The Santa Cruz Portland Cement Co., Devonport, Cal., has installed a system developed by Mr. F. H. Davis, manager, Mr. Fred Davis, superintendent, Mr. L. T. Bachman, chief chemist, and their associates. The collection here is effected by means of water, the distinctive feature of the installation being the use of excelsior beds through which the gases are made to pass after being scrubbed in a tower with water. The gases are first washed in the scrubbing tower by means of sprays and are then passed up through the excelsior beds which are 2 ft. and 6 ft. thick respectively. The solutions flow into a large sump, where solid matter settles, and are recirculated. The mud and liquor are pumped by means of diaphragm pumps to the tank of an Oliver filter, which separates the solids from the liquor. The former is burned to cement and the liquor is evaporated to dryness in a rotary kiln, which happened to be a spare unit in the plant and hence could be utilized for this purpose to advantage. The yield at this plant is about 4 pounds of potash salt per barrel of cement. The salts usually run about 36 per cent potash, principally as sulphate.

#### SPRAY TREATERS IN UTAH PLANTS

Messrs. Huber, Trainor and Fisher of the Riverside Portland Cement Co. have designed a spray treater which they are now installing at two plants, that of the Ogden Portland Cement Co. at Ogden, Utah, and the Utah Portland Cement Co. of Salt Lake City, Utah. This consists of two large brick chambers, the first of which is called the "saturater" and the second the "condenser." Each chamber is divided into four or six compartments by means of brick partition walls so arranged that the gases pass alternately from bottom to top of the large chambers. Sprays are located in the top and the corners of each compartment. In their course, the gases become saturated with water vapor in the "saturater" and then this vapor is condensed in

the second or "collector" chamber. The water is circulated over and over again and the potash collected as at Riverside.

Still another system for collecting the potash is employed by the Southwestern Portland Cement Co. at their plant at Victorville, Cal., which was worked out by Mr. J. G. Dean, chemical engineer of the company.<sup>1</sup>

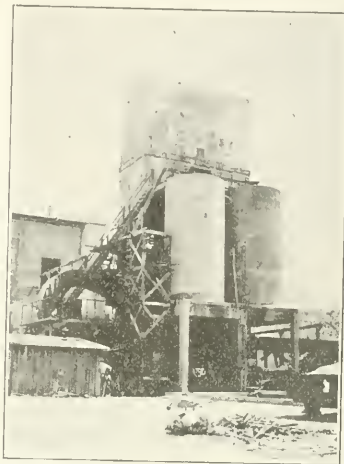


FIG. 2.—POTASH-RECOVERY APPARATUS, SOUTHWESTERN PORTLAND CEMENT CO.

The wet process of cement manufacture is employed at this plant. The gases issuing from the kiln, carrying from 30 to 40 per cent of water, pass through a condenser where this vapor condenses, probably around the dust and potash particles, and collects with the latter in the condenser tubes. The potash, of course, goes into solution and the dust remains in suspension. The condensed liquor is used as the cooling medium while the hot gases passing through the tubes are made to evaporate this solution. This is brought about by maintaining a vacuum above the latter, so that the apparatus is really a vacuum evaporator in which the kiln gases take the place of the steam ordinarily used. The solutions are concentrated in this evaporator to a density of about 1.1 and the evaporation is finished in an open-top steam evaporator provided with a salt box in which the potash salt collects and from which it is shoveled out when the box is full, allowed to dry in open air, ground and packed.

#### TWO POUNDS POTASH VOLATILIZED PER BARREL OF CEMENT

The quantity of potash volatilized at the average cement plant amounts to about 2 pounds of potash ( $K_2O$ ) per barrel of cement; or on the normal output of one hundred million barrels annually, the total volatilized in this country would be about 100,000 tons. Apparatus now available will catch from 60 to 80 per cent of this in water-soluble form. In 1918, 13,582 tons of potash material, equivalent to 1621 tons of  $K_2O$  and valued at \$700,523, was sold by the cement industry. In 1918 the production probably will be equivalent to

<sup>1</sup>"Wet Process for Extracting Potash from Cement Waste," By J. G. Dean, this Journal, Sept. 26, 1918.



about 3500 tons of  $K_2O$  valued at one million and a half dollars. When all of the plants now under construction are operating at full capacity the output will be equivalent to 10,000 tons of  $K_2O$  annually valued at present prices at about four and a quarter million dollars. There is a possibility of very materially increasing this quantity of potash by substituting for the shale and clay now used as raw materials certain materials of similar composition rich in potash, such as feldspar, sericite, certain shales found in Georgia and other states, leucite etc.

It may be of interest to note that largely through the efforts of Mr. R. C. Haff, chief chemist of the Security Cement & Lime Co., a rapid and very accurate volumetric method for determining potash in cement materials, dust etc. has been worked out. This method is a modification of the cobaltinitrite precipitation followed by titration with permanganate, as used in the laboratories of most of the eastern cement companies and has been found, as now modified, to compare very favorably with the platonic chloride method.

#### APPLICATION OF WASTE HEAT FROM KILNS

That the heat in the waste gases from the rotary kiln operating on the dry process represents about two-thirds of that supplied by the fuel used to heat the kiln has long been known, and various attempts have been made to utilize this heat in boilers. The first attempts were made at the plant of the Nazareth Cement Co. some twenty years ago and a little later at the plant of the Cayuga Lake Cement Co. Neither of these installations was entirely successful and both attempts were abandoned. Within the last few years, however, efforts to utilize the waste heat in boilers have been successful. The feature which seems to have made these latter installations successful where the earlier ones failed is the fact that the gases were led through the boilers at a fairly high velocity.

The method of using the gases for the generation of steam consists in drawing these through the boiler by means of a fan. The boilers are located as near the end of the kiln as possible and any dust which collects on the boiler tubes is blown off by means of steam.

In the newer installations it is found possible to produce practically all of the power necessary to operate the plant from the kiln gases. It is estimated that the installation of boilers after the kilns at all the cement plants in the country would save approximately one-third of the coal now employed in the cement industry, or about 2,500,000 tons of coal annually. Practically all cement manufacturers realize the vast saving which could be effected by the installation of waste-heat boilers. Unfortunately, however, just at this time it is almost an impossibility to obtain the boilers; moreover, the cost of installation under present conditions is such that the average cement plant does not find it easy to finance the undertaking.

It may be said that the waste-heat boilers and potash precipitation apparatus work very well together, as the flucs, dampers, fans etc. for one installation will serve for the other; and since the size of the dust treaters is proportional to the volume of the gases to be cleaned, the boilers will cool and hence reduce the volume of the gases enough to permit of very much smaller treaters being used. Such combined potash and boiler installa-

tions are now in operation at the plants of the Dexter Portland Cement Co., Nazareth, Pa., and the Alpha Portland Cement Co., Cementon, N. Y.

Baltimore, Md.

## The Annealing of Glass\*

GLASS has to be annealed to remove any strains set up in it by improper mechanical or thermal treatment, and the presence and development of strains is revealed by passing a beam of polarised light through the glass. Although this optical method of examination has long been applied by physicists and manufacturers of optical glass, it is hardly known to the average glass manufacturer. The Department of Glass Technology of the University of Sheffield has therefore investigated the annealing of glass and the relationship between the composition of a glass and the suitable conditions for its annealing with the special object of facilitating the optical examination and of devising simpler mechanical methods of testing. "Notes on the Annealing of Glass," giving an account of these investigations, were communicated to a recent meeting of the Society of Glass Technology, by Messrs. Solomon English, M.Sc., and W. E. S. Turner, D.Sc.; the latter is in charge of the Department of Glass Technology at Sheffield. Though these notes were only offered as introductory, the detail given are of considerable interest.

#### INFLUENCE OF MOLECULAR STRAINS ON POLARIZED LIGHT

In a polarization apparatus the beam of light, polarized by passing through the first Nicol prism, is stopped by the second Nicol, when the two are crossed. On introducing a cylinder of glass, strained with fair regularity, between the two Nicols, some light will pass and a system of colored rings will be seen, the number of rings increasing with the intensity of the strain. The strain can be removed again by proper annealing of the glass, and the glass manufacturer is mainly interested in three things: the "upper" annealing temperature at which the strain can rapidly be removed without risk of deforming the glass; the "lower" temperature at which the strain can be removed at a slow rate; and the quickest rate of cooling which may safely be used for cooling between the upper and lower temperatures without setting up new strains. For their optical examination, English and Turner use cylinders, 3 cm. in length, with plane polished ends which are placed in a tubular electric furnace. Such a specimen, if severely strained, will show seven rings and the central black cross. As the temperature rises, the rings broaden and seem to chase one another out of the field of view; the number of rings thus diminishes, they become indistinct and vanish, leaving only the black cross, which finally occupies the whole field; that is to say, the field is uniformly dark when all the strain has been removed. In the experiments the times were determined at different temperatures which were wanted both (a) for clearing the field of rings and (b) for making the field quite dark, and it was observed that a temperature difference of a few degrees in a lehr or other annealing oven made a large difference in the time required. Thus the results were:

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| Temperature,<br>Deg. C. | (a) Time Required | (b)                        |
|-------------------------|-------------------|----------------------------|
| 500                     | 20 5 hrs.         |                            |
| 550                     | 50 min.           | Not black after 0.5 hours. |
| 600                     | 20 min.           | 4 5 hours.                 |
| 625                     | ..                | 18 minutes.                |
| 650                     | ..                | 10 minutes.                |

The glass of these experiments was of a fairly high "upper" temperature. In a lead glass, the upper temperature of which was only 450 deg. C., the (a) were 35 min., 20 min., and the (b) more than 6.5 hours, 130 min., 2 min. at the temperatures of 400 deg., 425 deg., 450 deg. C.

Rapid annealing requires softening of the glass, and it was therefore investigated whether the rate of bending of heated sample rods and the rate of annealing would run parallel with one another. For this purpose a rod of the glass mounted axially in a horizontal tubular furnace, was fixed at the one projecting end, while the other free end played over a vertical scale; the sagging of the free end was measured. The general shapes of these curves proved the assumption just stated, and that glass anneals rapidly when the softening begins. Messrs. Beatson, Clarke and Co., of Rotherham, continued these tests. A test rod, 1 yard long,  $\frac{1}{4}$  in. in diameter, was drawn out from the metal in question, and supported at its center on a brick, which was placed on the pan carrying bottles down the lehr. Arriving at the cool end, the ends of the rod were each found to have sunk by  $\frac{1}{2}$  in.; in that case the bottles were found to be strained on examination. When the glass remained in the hot zone for about 15 minutes and was satisfactory, the ends of the rod had sunk by about 3 in.; with prolonged heating at higher temperature the bending became excessive.

#### RATES OF COOLING VARY WITH CHEMICAL COMPOSITION

As regards the rate of cooling, English and Turner find that the cooling rate should neither be uniform throughout the period, nor first be accelerated and then slowed down again, or *vice versa*, but that the glass may, first, *i.e.*, just below the annealing temperature, be cooled rapidly; as the glass stiffens the rate of cooling should be very slow until the glass has become rigid, when the rate may again be accelerated. Thus the rate of cooling should be variable. Three stages would probably prove sufficient. In the first stage, glass of an upper annealing temperature of 585 deg. or 590 deg. C. may be cooled at the rate of 25 deg. per hour down to 500 deg. C.; during the next stage 500 deg. to 400 deg. C., even a slow rate of 9 deg. per hour gave rise to some strains; in the cooling-off stage the rate could once more be raised. Each stage would correspond to a different section of the lehr, and the question is, whether the annealing oven can economically be so constructed as to admit of varying the rates of cooling. When only one variety of glass is made, the mechanical difficulties would not be great; but when glassware of different compositions and different thicknesses are to be annealed together, which is the common practice, the fastest rate of passage will have to be adopted, it is pointed out, even if this rate be that of the slowest glass to be annealed. How much the chemical composition influences these rates is shown by the data of the paper. A glass containing 30 per cent of lead oxide had to be annealed at 450 deg. C.; it could

be cooled down to 400 deg. at the rate of 120 deg. per hour, but between 400 deg. and 300 deg. the rate should not exceed 50 deg. per hour, while below 300 deg. the high rate of 300 deg. per hour was permissible. These figures concern a rod 7 mm. in thickness. For electric lamp globes this glass could be cooled at the rate of 12 deg. per hour down to 300 deg. C., and then be allowed to cool off in the open air. Wine glasses could be treated in similar ways. Lime-alkali glasses had to be cooled slowly, at 10 deg. per hour, from 550 deg. down to 320 deg., the further cooling being completed in 3 hours. Boric acid glasses (with 23 per cent of  $B_2O_3$ ) proved surprisingly difficult to anneal at 570 deg.; as borax acts as flux and diminishes the expansion coefficient of a glass, one might expect ready annealing; but the important factor is the rate at which the viscosity varies throughout the temperature range in which annealing can occur. Chemical glassware containing 64 per cent of silica, 10 per cent of alumina, 7 per cent each of barium and calcium oxides, and 11.5 per cent of soda and potash, proved the most troublesome; between 500 deg. and 400 deg. this glass has to be cooled so slowly that Messrs. English and Turner had so far failed to get an 8-mm. rod through this region without some signs of strain.

#### The Absent "C" in Germany

One of the peculiarities of the German language is the general absence of the third letter of the alphabet. As the ancient Huns became civilized, put on clothing and began to make a book of words, they thought that they could best teutonize the language of their neighbors across the Rhine by leaving out the "c's." Thus they changed cheese to käse, Caesar to Kaiser, cement to zement, came to kam, and so on. However, they made one great oversight and forgot to put the "k" in the right place in chemiker. Perhaps some scribe is to blame for this error but the theft could be made no more evident even by the bulging of the tunic.

Why the ancient U-boat navigator's vorvaters had this great aversion for "c" has only recently been discovered. You see the English controlled the seas and hence the German Huns couldn't use them.

Le Chatelier and Bogitch have adapted the Brinell ball test to the measurement of the hardness of bricks, by laying thereon a piece of thin lead foil, 30 mm. square and 0.05 mm. thick, previously blackened by treatment with hydrogen sulphide in a faintly acid solution, dried, and smeared with vaseline, most of which is wiped off again so that a matt surface is produced. The ball polishes the surface of the metal with which it comes in contact and this facilitates accurate measurement of the diameter of the depression. Tests with lead and copper showed that the foil does not interfere with the size of the depression produced. The ball used is 17.5 mm. diameter and is applied for 1 min. under a pressure of 500 kilos. The results are much more concordant than those obtained in determining the crushing strength of bricks. The test is useful in controlling the manufacture of bricks as it will show notable differences in the hardness of different parts of the same brick, due to irregularities in making or burning, or to an insufficient taper in the mould.—*Compt. Rend.*

# The Chemical Stoneware Industry and the War

Phenomenal Expansion of the American Industry—American Manufacturer Has Nothing to Learn from Europe—Standardization Desirable for Some Shapes—Domestic Materials Equal to Imported

By PERCY C. KINGSBURY

Chief Engineer, General Ceramics Co., New York City

THE OUTPUT of structural materials and equipment for chemical purposes has naturally received a remarkable stimulus from the phenomenal expansion that has taken place in the chemical and allied industries during the past few years. Obviously the extraordinary progress that has been made in the manufacture of chemical products has been dependent in a very large measure on increased production of the necessary plant and apparatus. It has also been dependent upon the efforts of American manufacturers to furnish equipment which had previously been imported from Europe. The success of most of these efforts is a gratifying tribute to the research departments of our large corporations and scientific institutions, the effect of which in rendering independent our future industrial development is almost impossible to exaggerate.

A result of this wonderful development has been that many minor industries in this country have assumed a position of the most vital importance. Of these the manufacture of chemical stoneware is one of the most remarkable.

Manufacturers were and are still unable to keep up with the sudden increase in demand for their products, this being due to no lack of initiative on their part as will be appreciated when some of the facts concerning this material and its production are taken into consideration.

A parallel condition was found among both groups of the belligerent countries in Europe. It has been intimated in the British technical journals that in England at the outbreak of the war, owing to the lack of suitable chemical stoneware equipment to remove noxious fumes, the workers in munition plants suffered severely in health. France, which depended almost entirely on Germany and Austria for her chemical stoneware requirements, has been obliged to turn over some of her world-famous china and pottery plants to the manufacture of this product.

Germany evidently realized the importance of this industry to the production of war materials. I have been informed that notwithstanding her need for men she exempted from military service the employees of the chemical stoneware plants in the country. She has also made a number of serious, but happily abortive attempts to tie up the production of chemical stoneware in this country.

## SERVICE REQUIREMENTS OF CHEMICAL STONEWARE

Before discussing the advance that has been made in the manufacture of chemical stoneware in this country during the war, let us decide what this ware is intended to comprise.

If the innumerable purposes for which chemical stoneware is used are considered, it is obvious that no one

body could possess all the necessary physical and chemical properties required.

This ware covers an entire range of ceramic bodies from the open structure bodies of a firebrick nature, used in the manufacture of vessels subjected to considerable range in temperature, to the dense bodies of a porcelain like nature used for electrolytic work. Within this wide range of products special bodies have to be devised to meet special conditions.

For instance, the low tensile strength of chemical stoneware as compared with metals is somewhat of a handicap that we can only minimize but not entirely overcome by skilful design. It has, therefore, been necessary to prepare mechanically strong bodies for use in the manufacture of such apparatus as acid eggs and impellers for pumps and exhausters that are subjected to considerable tensile stress.

The remarkable results that have been achieved along these lines are indicated by a statement by F. A. Whitaker at the last meeting of the American Institute of Chemical Engineers in which he gave comparative figures of the tensile strengths of English and German stoneware and the bodies that have been developed in this country during the past ten years.

## AMERICAN MANUFACTURERS EQUAL EUROPEAN

In every other respect also, the exigencies of the war have demonstrated that the American chemical stoneware manufacturer has nothing to learn from the European manufacturer.

At the Chemical Exposition is exhibited one of the largest pieces of stoneware (although not the largest) that has ever been produced in this country. It is doubtful if there are more than two other plants in the world that could manufacture a vessel of this size.

The design of stoneware mechanical appliances and machinery is complicated by the very high shrinkage that takes place during manufacture, which may vary from 8 per cent linear shrinkage or less for some clay bodies, to 16 per cent or more for others. This means that the greatest possible care must be exercised if strains in the finished ware are to be avoided.

In this field we have reason to be well satisfied with the progress that has been made during the war. There is now no stoneware mechanical appliance produced in Europe that cannot and has not been duplicated here. In a number of instances the design has been improved and further progress along these lines is under consideration.

An effort has recently been made in England to standardize such chemical stoneware shapes as is possible. This work was initiated by some of the smaller manufacturers and does not appear to be making much



headway, presumably through lack of encouragement from the larger manufacturers.

#### DESIRABILITY OF STANDARDIZATION IN SHAPES

That there is urgent need, however, for such standardization, only those who have to cater to the capricious demands of some of the users of this ware can fully appreciate. Taking as a simple example ordinary bell and spigot piping, some users demand a bell only 1½ in. deep while others using the same size pipe under substantially the same conditions insist on a depth of 5½ in. We find the same condition throughout our entire production. This means for the manufacturer the accumulation of an enormous stock of molds and the consequent increase in his overhead expenses, and for the user extra expense and delay which could well be avoided.

In view of the enormous increase in the use of chemical stoneware, particularly in connection with the manufacture of toxic gases and explosives, a review of the useful properties as well as of the limitations of this product may be of value.

The great advantage of chemical stoneware is its resistance to practically all chemicals met with in industrial work. In common with all silicious products, it is acted upon by hydrofluoric acid at all temperatures. It is also acted upon to some extent by phosphoric acid at temperatures above that at which chemical stoneware is ordinarily employed. Strong caustic alkalis, especially when hot, also have action upon it. When the conditions in regard to temperature and strength of solution are not too severe, the life of chemical stoneware when used for alkaline solutions is sufficient to justify the use of the ware for this purpose, but strictly speaking, alkali-proof chemical stoneware is a misnomer.

#### THE NATURE AND PURPOSE OF THE GLAZE

There appears to be a popular impression that the acid-proof qualities of chemical stoneware are dependent upon the glazed surface. The glazing should be for the purpose only of adding to the smoothness and appearance of the surface but should not be depended upon to improve the acid-proof qualities of the body. However, as a good deal of nonsense as well as deliberate misrepresentation has appeared on this subject, a few words might not be out of place.

The two methods employed are the application of a prepared glaze by means of a spray or brush, and salt glazing. The prepared glazes may be considered as clay bodies having a lower fusing point than the ware to which they are applied. At the temperature at which the ware begins to vitrify, the glaze melts forming a more or less homogeneous coating over the surface of the stoneware. This is nothing more nor less than a veneer or enamel and has all the disadvantages of enamelled ware in that the slightest scratch or pinhole, or other imperfection will allow the acid to penetrate to the surface beneath; and if the body is not properly vitrified and thoroughly acid-proof the action of the acid will ultimately result in the peeling off of the glaze. Cracking or cracking of this glazed surface is a natural and obvious result of subjecting such ware to changes in temperature.

Salt glazing is carried out by throwing common salt into the fire as the maximum temperature of firing is

reached. The salt volatilizes and the vapor reaches every part of the kiln where it is decomposed, the salt forming a double silicate with the alumina and other bases in the clay body, while dense fumes of hydrochloric acid gas pass up the chimney. A salt glaze is, therefore, a true glass intermolecularly combined with the body and one, therefore, which cannot craze nor peel. Moreover, as a salt glaze will not form on a surface that is imperfectly vitrified, this form of glaze is guarantee of the proper vitrification of the body.

#### DOMESTIC MATERIALS EQUAL TO IMPORTED

The idea, carefully fostered by those interested, of the superiority of imported raw materials, has been exploded in so far as it relates to the manufacture of chemical stoneware.

There was a time when we (I refer to the company with which I am associated) imported about 80 per cent of our clays. This was partly because they were cheaper than clays of equal quality of domestic origin, and partly because it was a good selling point, many of our clients being hypnotized by the popular bugaboo of the superiority of imported over domestic products. The imported raw materials we now employ are only a very small fraction of our entire consumption and are used only for a few special purposes. Domestic clays suitable for the manufacture of chemical stoneware are, however, not very widely distributed. Although our plants are situated in one of the greatest clay formations in this country, we can use comparatively little of the raw materials that are right at our door.

The expense of a long haul is, however, a great inducement to some other manufacturers to utilize local clays without due regard to their entire suitability. One of the difficulties thereby experienced is due to too short an interval between the temperature of vitrification and the softening point of the clay body. Thus the manufacturer using such clays who wishes to avoid deformation as much as possible, must be satisfied with incomplete vitrification, an attempt to improve the acid-proof qualities of his product by means of a heavily applied glaze. On the other hand, if he pays more attention to the proper vitrification of his product he cannot well avoid the distortion of the ware during firing.

#### HIGH DEGREE OF SKILL REQUIRED IN THE INDUSTRY

The present exhibition should do much to remove the prevalent idea that the manufacture of chemical stoneware as regards the necessary technical ability and skill is on a par with the manufacture of other clay products such as brick and tile. As a matter of fact the manufacture of this ware calls for a degree of specialized experience and painstaking skill exceeded by few other industries. This experience has in many cases been handed down from generation to generation; there are employed at the plants of our company a number of men whose forefathers worked at the first chemical stoneware plant in existence.

This is one important reason why it has been difficult to meet the demands of the chemical and explosives industry at the present time. This demand induced manufacturers of other ceramic products such as sewer pipe, brick and tile, fireclay, terra-cotta and hollow tile to enter the field. The efforts to adapt such plants which

are designed and equipped for the quantity production of a few simple shapes to a specialized industry such as this were foredoomed to failure, and this factor ultimately placed a still further strain on the few plants that possessed the necessary equipment, skilled labor and experience.

Moreover the entrance of such manufacturers into this field without the necessary experience and skilled help has undoubtedly done some harm to the industry as a whole, if such ware as they are able to turn out has been taken as a criterion of American chemical stoneware. There is little doubt, however, that the end of the war will also see the end of these peripatetic chemical stoneware manufacturers and that the industry will undoubtedly benefit from the demands that are being made upon it at the present time.

## Development of the Stoneware Industry

FIFTY-THREE years ago when the United States Stoneware Company was incorporated, the stoneware business was confined to the manufacture of crocks and jugs, and the maximum size it was thought possible to produce was a vessel of ten gallons capacity. Thirty years ago, however, this company conceived the idea that larger vessels could be made successfully and at once commenced experimenting. The result, through the aid of new methods, was a thirty-gallon crock. The demand for this vessel became so great for preserving meat, fruit, vegetables, butter, eggs etc. that its use became almost unlimited.

At this period the manufacturing of chemicals and explosives in the United States was in its infancy and the demand for acid-proof stoneware was correspondingly small. However, it was found necessary to increase the capacity of stoneware vessels to a still greater degree, the result being that to-day acid-proof stoneware is made to meet the requirements of customers in almost any desired form and size.

It may not be out of place to relate an incident that occurred back in the early 70's when Horace Greeley, the talented editor of the *New York Tribune* was the speaker at the exercises of laying the corner stone of Buchtel College in Akron, Ohio.

He ventured his conception of the process of making a stoneware jug: that a rope of suitable size was coiled in the form of a jug upon which clay was plastered, of desired thickness, and at the proper stage of dryness the rope was removed by drawing it out through the nozzle of the jug, being then ready for the kiln. A little later in the factory, however, he saw a jug maker standing on one foot and manipulating a pedal with the other, which caused a horizontal disk to revolve on which he was working a lump of clay with his hands through different stages until it became a finished jug ready for the kiln. He very amusingly admitted that the process of making a jug and his previous conception of it were much at variance. Thus verifying the fact that however wise one may be there is still more to be learned.

The process of making jugs and all other stoneware, to-day, is far in advance of that which was in vogue at the time above mentioned. Demand made it necessary to speed up, and processes employed now produce five

times as much stoneware in a given time. Perhaps no greater advance has been made than in the improvement of glazes.

Twenty years ago the U. S. Stoneware Co. became convinced that the cheap and ancient method of salt glazing which serves to cover up defects could be replaced with a glaze which would enter into and become a component part of the body of the clay. Thus began scientific experimenting which resulted in an exclusive glaze which displaces the antiquated salt glaze, the latter being the result of a few shovels of low-grade salt placed in the fire holes of the kiln which, at the point of burning off, fuses over the surface of the ware.

On the other hand the special glaze is applied to the ware in its partially dried state before firing and thus becomes a component part of the body of the ware. It is obvious that this system of integral, as well as a surface glaze, is far superior to a thin coating of salt glaze only.

We feel reluctant in mentioning the cruel war that the Kaiser has forced upon us and yet did we not condemn the atrocious military power of Germany which is striving to usurp the rights of the remainder of the world we should be lax in a duty which is incumbent on every patriot of the United States.

The impetus which the Kaiser's war has created in the many lines of business is recoiling upon him with tremendous force and will end in his defeat not only through force of arms but commercially as well. The slogan "made in Germany" has lost its effectiveness. Uncle Sam has awakened to the fact that he, too, can accomplish the difficult task of producing the numerous articles of commerce which formerly were an asset for Germany. The great resources of this republic protected as it must be by wise statesmanship will build up our industries and the United States will be known as the foremost nation of the world.

In meeting the requirements of the war the United States has certainly accomplished wonderful results. In every line the speeding-up process is going on to an extent that under other conditions would have been thought impossible. This connected effort to produce is perhaps no less pronounced in the line of chemical stoneware than in other important lines. The U. S. Stoneware Company has found it necessary to increase its capacity ten-fold that of normal times. When we have conquered the Kaiser, however, this condition may be changed to a certain extent, although the advances made in nearly every line of manufacturing which formerly went to Germany will be an asset for the United States.

## Direct Etchings On Glass

Diamond scratches are usually preferable to the usual wax and hydrofluoric acid etches because of being direct; however, by applying sodium fluoride in gum arabic paste to the glass surface, a platinum wire anode connected in electric circuit with the moist paste coating will liberate free hydrofluoric acid at the point of contact. With such an arrangement permanent and substantial marks can be directly placed on the glass. The cathode can be attached to a strip of cloth which the paste will cause to adhere to the glass.

## Home Made Optical Glass

The American Industry May be Epitomized by Saying that It Has Grown from Nothing in 1914 to an Export Business in 1918

By H. E. HOWE

SO SPECIALIZED has glass production become that window, plate, colored, heat-resisting, chemical, moulded, automatically-blown and optical glass each require their own organization for successful manufacture, and the trade merchandizing each ware is seldom fully familiar with other kinds of glass. The ultimate consumer, including the average chemist, has some difficulty in appreciating the differences.

Chemists are familiar, to be sure, with the research required to furnish glass having the peculiar characteristics of chemical glassware. But what of optical glass? In order that what has been accomplished in America in the past four years may be more fully appreciated, it will be useful to review something of the past one hundred years in optical glass.

Prior to 1870 there were but three notable exceptions to the general apathy in devising new types of optical glass. These were Fraunhofer, who had partial success but who failed to produce anything commercially and whose formulae were lost; an English committee headed by Micheal Faraday in 1825; and an English clergyman, Harcourt. Although the report submitted by Faraday in 1829 was of small practical value, it did have important directive influence. Harcourt was handicapped through lack of guidance to be had only from the spectrometer which was not available because his meltings were too small, but he recorded much of value and was one of the very first to experiment with new elements. We may say, therefore, that until Abbe's appeal in the late 70's, the impetus to improvement in optical glass may be credited largely to the Anglo-Saxons.

The efforts put forth by the glass makers concerned diminishing the color, increasing clearness and homogeneity in well-known crown glass and in obtaining greater refractive power and dispersion in flint than had been customary, but no one cared to experiment with new elements and compounds against which there was much prejudice. Crown glass was composed of potassium carbonate, with perhaps some sodium carbonate, lime and silicic acid. Flint contained no lime, substituting lead oxide therefor. Of course, many variations in amounts were used but there is no evidence that, excepting in an experimental way, any other elements than those named had been employed.

Abbe's appeal was from a scientific viewpoint, and without discussing the commercial aspect he emphasized the need of new materials with which to construct new microscopes etc. to be used in furthering scientific progress. Manufacturers were then, as today, reluctant to spend money on research without advanced guaranteed profit, and in this case there was no promise of large returns even if successful. It was fortunate, therefore, that Schott, the son of a glassmaker, was

attracted by the appeal and that the research work had the financial aid of the Prussian Bureau of Education and the Prussian Diet.

Until this work began, Germany was no better than second in optical glass production, France being the leader. But as in so many other instances, concentration with scientific method and ample finances was to lead to success.

### LIMITATIONS OF OPTICAL GLASS

It will be helpful here to mention some of the factors in the problem and then a little of what was undertaken under the name of the Jena Glass Laboratory. The glass flux must not act upon the material of the pot or crucible and in this manner absorb impurities. Elements which evaporate during the melt have a tendency to produce veins and so must not be used. These so-called veins or striæ or cords, as they are variously known, are of no consequence in many kinds of glass, but optical glass must be free from them and the slightest indication of them results in the glass being discarded. Large bubbles must be avoided, and all bubbles as far as possible, while for telescopes, microscopes, binoculars, eyeglass lenses and wherever the light is to be transmitted to the eye, no bubbles can be tolerated. Cloudiness, crystallization and any liability toward devitrification in the process of melting, cooling and subsequent re-heating must be avoided. The glass must be such that no stress will be produced when it is brought from the plastic to the solid state and it must not be hygroscopic or tarnishable in ordinary atmosphere. Optical glass must be as colorless as possible, although other characteristics are at times so desirable that color becomes a secondary consideration, as in special flints. Besides all these limitations, the product must have strength enough to bear the manipulation necessary in grinding, polishing, mounting etc.

Furthermore, refractive index, dispersion, absorption of light and density are values which should be maintained as constant as possible in successive melts of the same composition, for it is largely upon these values that the optician makes his choice and calculates his lens elements accordingly. For some optics it becomes necessary to refigure formulae for slight changes in these values between different melts and even to reconstruct grinding and polishing tools.

### EARLY EXPERIMENTAL WORK

When Schott and Abbe began their work, silicic acid was the only glass-making acid oxide in use. There was a tradition that boric, phosphoric and arsenic acid gave tarnishable glasses and, with the exception of Harcourt, no one had done much to determine the in-



fluence of the different metallic oxides upon the physical constants of optical glass. The first experiments were along this line and had to be empirical. They included the use of all the glass-making acid oxides with the oxides of boron, phosphorus, lithium, magnesium, zinc, cadmium, barium, strontium, aluminium, beryllium, iron, manganese, cerium, erbium, silver, mercury, thallium, bismuth, antimony, arsenic, molybdenum, niobium, tungsten, tin, titanium, uranium and fluorine.

The meltings were just large enough to yield pieces for spectrometric and refractive measurements and were made in porcelain, fine clay and platinum. The elements were introduced gradually in quantities of at least ten per cent and many were eliminated very early on account of rarity, volatility or coloring influence. It soon began to be demonstrated that the hitherto fixed relation between refraction and dispersion could be varied and that both ends of the spectrum could be lengthened.

The problem of new compositions was accompanied by that of providing suitable melting pots, technique in stirring and heating and in annealing to eliminate stresses. Special clays, "ripened" and carefully blended, make the final type of pot which required eight to ten months from the time it was laid down until ready for the furnace. After a great many trials and tests with polarized light, fine annealing was developed. It was determined that the temperature of solidification lay between 370 and 465 deg. C. and that by spreading the fall of 95 deg. over an interval of four or more weeks perfect results could be obtained. Accordingly, ovens were built with thermo-regulators and devices whereby they could be maintained at any point between 350 and 477 deg. C. and allowed to cool with any desired slowness.

#### NINETEEN GLASSES DEVELOPED UP TO 1886

Up to 1886 the net result of all this tedious work was nineteen glasses of essentially new optical properties. These may be roughly divided into four groups, flint containing boric acid, borosilicate crown, dense barium crown and phosphate glasses.

Flints containing boric acid are not so durable as the older types, but with them it is possible to make three lens objectives free from the secondary spectrum. The borosilicate crowns are important and find use in small objectives, prisms etc. They are of lower refractive index and dispersion than the ordinary crown glasses.

Dense barium crown glass contains barium and boric acid and is used in practically all anastigmat photographic lenses, but in order to obtain the necessary optical qualities it becomes necessary to approach very near to chemical instability, and this leads to difficulties in manufacture. The phosphate glasses proved unstable and subject to deterioration in use.

Since it would be an advantage if it were possible to compound a glass that would have certain calculated characteristics, efforts have been made to determine whether the characteristic of metallic oxides are persistent to the same degree in glass. Density, tenacity or tensile strength, resistance to crushing, elasticity, hardness, specific heat, conductivity of heat, cubical expansion, thermal endurance and chemical behavior have been carefully studied. In each instance the

properties have been determined from observations on properly selected glasses, and from the data thus obtained values have been assigned to the oxides. Other glasses have then been compounded with relation to these values and the results then compared with what had been expected from the calculations. Unfortunately, in practice the plan does not work out very well, although computed results differ in some cases from those observed by no more than 1½ per cent. The maximum difference, however, occasionally runs above 40 per cent.

#### RELATIVE INFLUENCE OF ELEMENTS ON GLASS

The elements having the greatest influence on the density of glass are barium and boron, while sodium and arsenic have the least influence. Calcium appears to have the greatest bearing on tenacity, and magnesium the least. Aluminium is responsible for the greatest hardness and calcium for the least. Auerbach fills the large gaps in the middle parts of the Mohs scale of hardness by inserting a crown glass between quartz and feldspar and two flints between apatite and fluor-spar. With these additions the scale in ascending order is gypsum, rock salt, calcspar, fluor-spar, two flint glasses, apatite, feldspar, crown glass, quartz, topaz and corundum.

Silicon has the greatest influence on resistance of glass to crushing, and potassium the least. Magnesium oxide appears to impart the greatest elasticity to glass, and zinc the least.

To determine the thermal endurance, polished cubes are heated to ascertain the greatest difference in temperature they can stand without cracking. Some glass can withstand a sudden rise in temperature far better than a sudden lowering of temperature, and the more the difference exceeds that temperature which can just be borne, the greater are the number of cracks produced. One glass, which in testing could withstand a difference in cooling of but 52.8 deg. C., was able to withstand a sudden elevation of 465 deg. C.

#### GLASS A SOLID SOLUTION

Glass is undoubtedly a solid solution in which silicic acid or other acid-forming oxide is the solvent. This accounts for much of the behavior of glass, such as the lack of homogeneity in optical glass. This improves as the glass ages, and since a readjustment of the molecules is rendered much more difficult in glass than in a liquid solution, a comparatively long time is required for the proper aging of optical glass. When this aging does not accomplish sufficient homogeneity, the optician produces an optically plane surface by means of local corrections obtained by hand polishing and frequent testing of the results thus secured.

The production of these new glasses to which others have since been added was taken up by Schott and Genossen with much success, stimulated by the demand for many new optical instruments made possible with the glass. It was thus that Germany soon became the world center not only for such glass but for all classes of optical instruments as well.

The French and English factories devoted their attention to specialties or, lacking an advertising bureau equal in efficiency to the German, made equal glass unknown except to old customers. It would be

worth knowing whether back in the 70's the Prussians had military optics in mind when their government helped to finance Abbe and Schott in their experiments!

#### MILITARY DEMAND FOR OPTICAL GLASS

When 1914 came, ordnance had been developed to a point such that whereas in our Spanish war 5000 yards had been considered a maximum range, we must now have range finders capable of reading accurately to 20,000 yards if they are to be efficient, and this necessitates high-grade optical glass in quantity to keep pace with the requirements of modern sized armies.

For some time, a few men had thought of producing optical glass in America. The glass companies could see no reason to finance the necessary expensive experiments unaided by the consumer, especially when the annual requirements were relatively small and no market was actually assured. Those using such glass were satisfied with their source of supply and consequently the little work that had been done was unsupported and half-hearted. Even after the war began, those vitally concerned retarded developmental work, strong in the belief that the war would be but a matter of weeks and the old source of supply soon again available.

Then came the demands of the Entente for range finders and binoculars beyond the capacity of their own or American optical works. Glass stocks melted away. The British Advisory Council recognized both chemical and optical glass manufacture as key industries and plunged into research and technical experiments. We began to realize that the best optics, even in our own military establishment, were made with Jena glass; that no more of that glass was forthcoming and that if business, our only consideration at that time, was to continue, we must make glass.

Fortunately, in the writer's opinion, there was in America a Belgian who had come here years before hoping to engage in the manufacture of optical glass. He was a technical man, and after making plate glass here in the absence of interest in American optical glass, he had returned to his ideal and was conducting some experiments in 1914. Engineers were called in, a larger plant provided and, inadequately assisted, this man began the commercial scale production of optical glass in America.

#### OBSTACLES TO BE OVERCOME

If error and failures were not to be expected, then the magnitude of the difficulties to be overcome has not been set forth with sufficient clearness. True, the work that had gone before was of immeasurable value and the new starting point well advanced, but formulae had never been published and were considered part of the stock in trade by European glass makers; a chemical analysis of such a complex silicate can do little more than furnish guidance in making up a melt. It seemed to require an unduly long time for the necessity of pure raw materials to become impressed upon the minds of those engaged in the work, whereas the very nature of the product requires careful control in this regard as had been made a point of importance by those propagandists interested in convincing America that optical glass was altogether too difficult a product to be attempted here. Sands thought to be of excep-

tional purity by the usual glass maker were found to contain sufficient iron to condemn them for optical glass where freedom from color is a requirement and no decolorizers such as manganese can be permitted. Lead oxide for flint glass must be of high purity and quite free from metallic lead, and so with item after item there are substances very likely to be present which can not be tolerated.

And pots! One of the large problems of the entire glass industry involving the study of clays which one well-known ceramic engineer says no one knows much about, least of all chemists. A large number of pots are required, for the usual practice is to allow the melt to cool in the pot which is thereby destroyed either during cooling or in breaking up and sorting the glass. Pots are of two types and are about 40 inches in diameter and height, though smaller ones are frequently used. The open pot is used for those melts not subject to the action of the products of combustion, while the closed or "monkey" pot affords almost complete protection, the only opening protruding at the side. Many pots have been made and used in less time than has ever been thought possible, and there have also been delays due to the breaking of these green pots in the melting arches.

Then there have been temperature problems, troubles with refractory brick and cement in the furnaces and all those factors which enter into the use of high temperatures under control. One of the tricks of the trade is the proper stirring of the melt. A water-cooled, fire clay stirrer is employed and this must travel in ever changing circles propelled by hand or power through a mechanical device. The European practice leans strongly toward hand-stirring because of the care required not to approach the pot walls too closely, thus bringing into the melt traces of the dissolved clay, and to vary the manipulation in accordance with changing conditions within the pot. Properly supervised mechanical stirring has given good results however.

#### REVIEW OF PROGRESS

What has been the progress under the stimulation of necessity in rapidly providing a key industry? The Bureau of Standards took up a portion of the burden, various glass makers began serious work, and through the solicitation of the members of the Naval Advisory Board, the Geophysical Laboratory of the Carnegie Institute applied its very considerable resources to the assistance of those already engaged in commercial scale experiments. America began to overcome her shortage of optical glass. There were and still are many problems. Some difficulty has been experienced in bringing glass makers of the old school to realize the exactness of the new requirements. "It is only a small bubble," but you can not have it in an eyepiece. "Just a single string," yet the presence of any striæ in a prism renders it unfit for range finder or binocular.

Prices have gone up and up, but not out of proportion to advances in cost of labor, fuel, raw materials and other items of production. For some grades of glass 20 per cent usable is considered a good yield, though this is materially increased in most instances. Output has been concentrated on glass used for military instruments and eye glasses and at the time this is



written America is in a position to satisfy her own requirements, to help her Allies and to export optical glass! One plant as early as February of this year produced more than sixty tons in one month; moreover, as many as six plants, great and small, are now at work, although some are not making much of a profit as yet, for the expense is heavy, the output small and the field restricted.

Other varieties of glass for microscope and photographic lenses will be added later, but meanwhile we are exploring new fields. One manufacturer has perfected methods for casting some optical glass very much as plate glass is poured on large casting tables and rolled out before annealing in a large sheet. This sheet or plate is then ground and polished, defects cut out and the remainder cut to size for final inspection. This has several advantages over breaking the glass to weighed portions and moulding these to size and shape or even sawing, notwithstanding the large loss in the grinding and polishing operation, amounting as it does to about 50 per cent of the melt.

The Bureau of Standards has undertaken research on glass pots with special reference to increasing the life of pots. Small-scale work with porcelain has yielded results which look promising.

From nothing in 1914 to ability to export in 1918 is a brief way of expressing what has been done. The key industry has learned to walk and we shall be able to make military optics to help us reach the Hun no matter how far he may run. This is the open season for German monopolies and they are being broken even as a good marksman shatters clay pigeons.

Cambridge, Mass.

### The Manufacture of Beakers

The question as to the thickness of the beakers and flasks has been the subject of careful consideration. Bohemian ware was always very thin, as the glass from which it was made was not resistant to heat. With resistance glasses it is possible to make beakers and flasks very much heavier than the Bohemian ware, and in this respect we, and the American manufacturers, have followed the practice of the makers of the Jena glassware. A 500-c.c. beaker should be about 0.8 mm. thick, and a 1000-c.c. beaker 1.0 to 1.2 mm. thick, but the articles must, of course, be evenly blown. Such articles as graduating flasks and X-ray bulbs must be blown exact to weight.

When a beaker is blown, it resembles a bottle, and the next stage in the process is to cut it to the proper height. The article is slightly scratched with a diamond, and placed on a revolving table, while a fine blowpipe jet plays upon it at the height of the scratch. If the goods are well annealed, and evenly blown, they crack off quickly and evenly, provided that the jet is properly adjusted. Badly annealed goods and badly blown goods crack off so as to leave jagged edges. Thus the efficiency of production depends very largely upon efficient first annealing.

The flanging and lipping of beakers, and the flanging of flasks, are operations which are carried out entirely by machines operated by girls. The designing of these machines did not call for a vast amount of ingenuity, but in perfecting the details it was necessary to study the processes very closely in the works.—*Jr. Soc. Chem. Ind.*

## Industrial Glassware

By S. R. SCHOLES

AMONG the lines of manufacture in America that have been greatly stimulated by conditions arising out of the great war is that of glass for industrial purposes. We imported most of this glassware before the war closed the European sources of supply. Perhaps the chief reason for that dependence upon Europe was the low tonnage estimated in making such ware. We were accustomed to producing tons of steel, while we imported cutlery. Similarly, we produced great quantities of plate and window glass, bottles, packers' goods, lighting glassware, tableware, even fine blown and cut glassware, because the demand was great and the tendency toward large-scale production, involving machines, could have full swing; but we imported scientific and industrial glassware, largely because we regarded the business as too small for consideration.

Another reason for hesitancy in entering competition with European workers lay in the fact that a large part of the scientific glassware came into this country duty-free, and therefore it was practically impossible for us to produce it, on account of the higher wages paid American workmen. Since the character of the glass itself which entered into scientific utensils and instruments was much the same as that required in the industries, this had a direct bearing on the production of industrial glass.

### STRONG DEMAND AT GOOD PRICES

An abrupt change took place when the war began in 1914. Not only were importations stopped, but also foreign competition. American manufacturers were both obliged to meet a new demand and allowed to obtain prices which warranted them in doing the necessary development work. Further incentive came from the expansion of chemical industry. New processes and enlarged plants required special pieces of glass apparatus and parts, and larger quantities of standard articles. The same effect was produced by the general expansion of the industries in 1915 and 1916. More steam boilers meant more gage glasses, more motors and machines, more oil-cups. When America entered the war, still further stimulation along special lines, especially optical glass, was manifest. The result has been that this country is rapidly approaching independence in the matter of glass for industrial purposes—if indeed that is not already attained.

However, the manufacturers did not at once grasp the situation to their full advantage. The wave of prosperity that began in 1915 brought a greater demand for glassware for household use, and factories whose equipment would have enabled them to produce large quantities of glassware for technical use declined at first to enter the field. They were busy enough as it was. In those days, few realized the length of war-time ahead, and peace seemed always only a matter of a few months. Therefore, it was argued, why waste money preparing for a business that could only be transient? But the demands of industry for glass became more insistent, and, with the curious reluctance toward the new and unfamiliar that has always seemed to characterize the makers of glass, they were supplied.

Discussion of the varieties and properties of indus-



trial glass in this article may well leave out optical glass, for that exceedingly important field has been well covered by the men who have so ably risen to the emergency and brought out with speed and thoroughness the vitally necessary glass, without which our best ships and guns would have been as futile as the blind. If ever in the future government appropriations for the bureaus engaged in purely scientific research should be grudging, their supporters need only point to 1917 and optical glass!

#### PHYSICAL REQUIREMENTS AND COMPOSITIONS OF GLASS

Glass for many, if not most, of its industrial uses requires exceptional strength, a low coefficient of expansion, and resistance to the attack of solvents of all sorts. It must be thoroughly annealed, for a residuum of internal strain that would be harmless in a window pane of a piece of table glassware, might be fatal in a gage-glass or a sight-feed tube. The articles themselves must be made to an accuracy of dimension approaching that of machine parts, a condition very unusual in ordinary glass articles.

The composition of glass to meet the requirements outlined is comparatively simple, although quite different from ordinary glass, such as would be found in bottles, for example. It is an old practice in this country to make a heat-resisting glass out of sand and borax. Such a glass is a sodium boro-silicate, and may be considered the foundation or type of heat-resisting glasses in general. The boric oxide serves a two-fold purpose: It replaces the alkali to some extent—the alkali is the constituent of glass having the greatest coefficient of expansion; boric oxide itself has the lowest. Another fortunate fact, is the reduced solubility or increased resistance to water and chemical reagents of the boro-silicates compared with the simple silicates.

The improvement of this sodium boro-silicate glass was the main problem to be solved. If pure fused silicate could be worked at a reasonable temperature, it would represent very nearly the ideal glass for industrial use. The more nearly its properties, except, of course, its softening temperature, are approached by any glass, so much the better for its durability. Therefore, the best heat-resisting glasses contain high percentages of silica, sometimes as high as 80 per cent. This makes them rather hard to melt and to work, but this very fact increases their utility for many purposes. In order further to decrease the solubility of these glasses—a very important matter in the case of gage-glasses, for example—it has been found advisable to add certain of the insoluble bases, such as alumina, zinc oxide, and magnesia.

The results reached in American factories are several closely similar heat-resisting glasses which are also very stable and resistant toward water and reagents of all sorts and toward high-pressure steam. So far as glass compositions go, American wares are now highly satisfactory. They are superior, in some lines, to the best that were ever imported.

Annealing is a matter that now receives more attention than formerly, for many failures of glass articles can be laid to the internal strain left by insufficient annealing. This, as everyone knows, must be removed by heating the ware to the initial softening point of the glass, then cooling it so slowly that both interior and surface portions of each piece reach the rigid condition

at virtually the same time. With the devices now obtainable, which make use of polarized light for detecting strain, glassware can be examined before it is sold, thus eliminating one source of loss and disappointment to both maker and user.

Accuracy of size and uniformity of thickness in glass articles require painstaking skill on the part of mold-makers and glassworkers. The developments here are also gratifying. When they have become convinced of this necessity, American workmen have taken a live interest in methods of manipulation to secure it, and have shown that there is little reason left to mourn the lack of imported ware for its workmanship.

#### TARIFF NECESSARY TO OFFSET OUR LABOR COSTS

There are no statistics available, but it is certain that the volume of business in glass for industrial uses is very large. It is also growing. The production of heat-resisting glass that will stand sudden and extreme changes in temperature has been followed by new applications for such glass. Many pieces coming under the general head of "sight-feeds" are being made, enabling the operators to see and thus control many processes hitherto "in the dark." Now and again a use is proposed which no glass can be expected to fill. On the other hand, glass parts could undoubtedly be introduced in many places in large scale chemical apparatus, where visibility is desirable but not now possible.

Summarizing the effect of the past four years on this phase of the glass industry, American manufacturers have proven themselves capable of supplying their country's needs, and have even gone farther and created new and better glasses than are made in Europe. A list of the varieties of glassware now made here that were not made to any extent in this country before the war, is given in the recent report of the Tariff Commission on "The Glass Industry as Affected by the War": Optical glass, laboratory or chemical ware, glass gage tubing, watch crystals, glazing glass, oven glass, glass brick, siphon bottles, photographic glass, and high grade picture glass and glass for spectacles.

This is an expansion worthy of note, and it has come in no sudden or spasmodic manner. It rests on a good foundation of careful study and work. The question of competition with Europe in industrial glass after the war will depend only upon price, for the quality of ware is assured. There must be, it is evident, a retention of suitable import duties to be paid by all alike. The unreasonable duty-free privilege, which discriminates against American manufacturers in favor of Europe and Asia, must be abolished. Then this healthy growth can be retained as a permanent branch of the glass industry in America.

#### Substituting Imported With Domestic Clays

In the past few years, many types of clay have been found in South Carolina and Georgia. Unfortunately, no suitable descriptive nomenclature other than Dry Branch, Gorden, Langley etc. has come into trade use. As the past geological experiences of a clay deposit controls the physical properties of the clay and no two deposits have been subjected to identical conditions, it follows that some judgment must be exercised in selecting a clay having properties similar to some particular foreign product.

## Recent Developments in the Manufacture of Chemical Porcelain

BY JOHN C. BAILAR

SOON after the outbreak of the present war, when German commerce was swept from the seas, any man who had a piece of chemical porcelain "Made in Germany" was inclined to keep it under lock and key. It would be decidedly inconvenient to run a laboratory without it and no one knew when or where more could be obtained when the supply on hand should be exhausted. But unknown to the scientific world the seeds of the chemical porcelain industry had already been planted in this country.

In the winter of 1910 a potter went to Golden, Colorado, seeking health. In order to pay expenses, he repaired an old pottery kiln that had long been in disuse and began the manufacture of cooking utensils on a small scale, he being the only workman in the plant. In 1911, the writer, struck with the excellent quality of the ware, suggested that he try some chemical porcelain. A few small crucibles were made using the same body and glaze that were used in the cooking ware. These were taken into the laboratory and given a thorough working test. As was to be expected, some of the test samples failed utterly, while a few compared favorably with the Royal Berlin porcelain that was in general use at the same time.

This showed the possibility of making good laboratory ware of the clay, and experiments were carried on in connection with the routine work until 1914, when the business was taken over by a company organized by Mr. Adolph Coors. The plant was enlarged as rapidly as possible, and early in 1915 was given over exclusively to the manufacture of chemical and scientific porcelain. That the venture has been a success is attested by the fact that the company now has twelve large kilns running at full capacity. This company maintains a large research department and the policy has been to perfect one article before beginning another. For example, in the beginning, only small crucibles, casseroles, and evaporating dishes were made and not until these were of the very best quality did the research department turn its attention to anything else. The high quality of the ware is due largely to this policy. The brain power of the entire force is focused on each article before it is given to the public.

### AEROPLANE SPARK-PLUGS

The research department, under the direction of W. J. Hazard, is now concentrating on a porcelain spark-plug for aeroplanes. The object sought is a spark-plug that will stand up under fifty hours' continuous use, besides being resistant to hard knocks and having several other properties desirable in spark-plugs. Present indications are that this plug will soon be on the market. The best porcelain aeroplane spark-plugs now in use are good for about thirty hours.

Coors chemical and scientific porcelain is now sold by practically every dealer in the United States, as well as in the principal cities in Canada, Mexico, South America and the war zone in France. The company manufactures all the wares used in the laboratory and plant, and stands ready to make any special apparatus ac-

cording to specifications. Special mention should here be made of the porous ware made by this firm. In comparative tests made in the United States mint, this ware lasted five times as long as the Royal Berlin. Some electrolytic processes have been completely revolutionized by the use of Coors porous vessels.

### LOCAL MATERIALS USED

The materials used by the Coors Company, except a small per cent of the glaze, are found within five miles of the factory. The clay is of the same formation as that from which the Golden fire-brick and assay crucibles are made. Concerning the latter ware a writer once made the following statement: "Mining engineers are in darkest Africa, in central China,, in the plateaus of the Andes and the steppes of Russia, but they have not yet got beyond the zone of the Colorado-made assay crucible." This is not a figure of speech but a plain statement of fact. In 1916, owing to the peculiarities in freight costs of transportation companies, both English and German assay crucibles were offered in the western United States for a less price than was asked for the home product, made from Golden clay; nevertheless they found no sale. But perhaps fire-clay goods should not be included in chemical porcelain.

### THE GUERNSEY CO. TAKES UP CHEMICAL-WARE

In contrast with the Coors pottery, the Guernsey Pottery of Cambridge, Ohio, was well established at the beginning of the war. They were making, among other things, high-grade cooking utensils. Realizing that there would soon be a demand for laboratory porcelain, this company lost no time in making such readjustments as were necessary. The change from cooking utensils to chemical porcelain was not great and by the time the last cargo from abroad was unloaded, they were in the market with porcelain that showed better tests than any "Made in Germany." During the past year there have been substantial advances in both quantity and quality of Guernsey ware. They now advertise "more than three hundred different items," which number ought to give variety enough to satisfy the demands of the most exacting chemist. The products of the Guernsey and the Coors companies have been tested and approved by the U. S. Bureau of Standards.

If the need should arise, either the Guernsey or the Coors pottery could supply the needs of the United States, leaving nothing to be desired in either quality or quantity.

In addition to these two firms, other companies are turning their attention to laboratory ware and neither the analyst nor the manufacturer need have any fear of the future. It can safely be predicted that if any German laboratory ware should ever find its way into this country, it will be given the same reception that was given to German fire-clay goods in 1906.

Research Department,  
Great Western Sugar Co.,  
Denver, Colorado.

**Scratches on the Ground.**—Clay has been an important writing material throughout all the ages. The sheet of paper on which this is printed is essentially kaolin in a more convenient form than the bricks of the library of Ninevah.

<sup>1</sup>Non-Metallic Minerals of Colorado, *Western Chemist and Metallurgist*, Vol. IV, page 330.

## Chemical Stoneware\*

### Preparation and Selection of Materials, Acid-Resisting Tests, and Annealing Ware

By A. MALINOVSKY

THE manufacture of chemical stoneware is a separate and distinct branch of the ceramic industry. It is a branch that has received but scant attention in this country as most of this class of ware was imported. Now that importations have been cut off, it is essential that we produce chemical stoneware equal if not superior to the imported article. This must be done if the chemical industry is to continue its growth and supply us with the many chemicals that have heretofore been imported or made in limited quantity only.

Chemical stoneware is made in a great number of shapes and sizes, ranging from the simple evaporating dish to the most intricate arrangement of pipes and vessels and to containers of great size. It requires a skillful workman for building up these various shapes and the utmost care in handling and burning them; but more than anything else, it requires the close and careful attention of a competent ceramic chemist to make selection of raw materials, supervise mixture and manufacture, from grinding to firing and to vary the processes to produce ware that will fulfill the requirements of the particular use to which it is to be put. A good chemical stoneware should resist the action of hot and cold acids of all kinds (excepting hydrofluoric acid), be able to stand sudden changes in temperature, and be impervious to moisture.

#### THE SELECTION AND MIXING OF CLAYS

It is the usual practice to mix different clays to produce a body similar in character to porcelain; therefore, mostly those stoneware clays are used which contain enough flux to produce, at a high heat, a body with a very close structure. If stoneware clays are not at hand, a low grade of fire clay can be substituted. The fire clay is burned at about 1400 to 1500 degrees centigrade, at which temperature the iron and other impurities will act as the flux; or the fire clay can be mixed with an impure clay which has a very low fusing point. In this case the fire clay serves as the skeleton to preserve the shape of the articles from deformation, whereas the impure clay serves as the flux which at a high heat binds the particles of the fire clay into an impervious body. Other cheap fluxes can be added such as lime, or furnace slag, since the color is of no great importance. In this latter case, there is a chance for the acid to attack the iron and subsequently the clay body, thus disintegrating the whole body to a sponge-like mass.

Great care should be taken to produce a uniform body, since this is very essential in the manufacture of chemical stoneware. The best result is obtained by mixing and blunging the mixture, or only the fusible part, which will be the fusible clay (preferably all the mix should be blunged), and by then screening in order to remove all coarse particles. The surplus water is then removed with the filter press.

It is very necessary to screen the clay and remove all the coarse particles, particularly when taping and faucets

are required which must be made to fit tight. The spigot and faucet are usually made from the same material as the body, some manufacturers preferring to grind the material finer for the spigot and faucet than for the body. The joints in spigots or faucets have to be ground with water and sand or emery to make a close fit. If the coarse material is not removed, tight fitting of spigot or faucet will be impossible.

The body mix should be high in silica and yet plastic enough to permit the shaping of large pipes and vessels, such as still condensers, acid containers and other vessels used in the chemical industry. At the same time it should possess an interval of from 200 to 300 degrees centigrade between complete vitrification and deformation.

#### NEW MATERIALS SUCCESSFUL

It is in this interesting field of ceramics, more particularly refractories and chemical stoneware, that the writer has been doing research work during the past several years of strife. The company with which I am connected has undertaken the development and perfection of processes by which certain waste materials and minerals, heretofore unutilized, can be employed in making various ceramic products.

It is gratifying to be able to say that our efforts have been successful. Many tests of the ware, both in the laboratory and under actual working conditions have given results comparable with the best imported products. Materials from many different states have been used in this connection and their suitability under the process proven.

The composition of the stoneware is highly vitrified and the ware has a structure similar to that of igneous rocks, excepting that it is more nearly homogeneous. It can be made of as close and fine grained a structure as porcelain. This stoneware consists of unfused and fused particles, held together by a vitreous bond. The different mineral particles are enveloped by the fused particles, giving a strong interlocking structure which resists the action of moisture and of acids.

#### SOME SOLUBILITY TESTS

A test made by the author in our own laboratory yielded some interesting results. Two crucibles and one vase were placed in a gas fired dry oven and were gradually heated for 72 hours to 110 degrees centigrade. After they were allowed to cool in the oven to 90 degrees centigrade they were placed in a large jar until cooled to room temperature and then were carefully weighed. The small crucible weighed 192 grams; the large one 934 grams, and the vase 621 grams. The crucibles and vase were immersed in water for 48 hours, then removed, and, after drying the surface with blotting paper, carefully weighed again. The results obtained indicated that the large crucible had 0.856 per cent absorption, the small one 0.521 per cent, and the vase 0.0325 per cent. The same crucible and vase were again dried and weighed as before. The large crucible was found to weigh 933.542 grams, the small one 192.000 grams, and the vase 620.372 grams.

They were then filled with commercial concentrated sulphuric acid, 66Bé., and the two crucibles placed on a 14-inch iron pan filled with sand. Two inches of sand separated the test pieces from the pan. Heat was ap-

\*Read at the June meeting of the American Institute of Chemical Engineers, Gorham, N. H.



plied and boiling continued for a period of 12 weeks. The temperature of the sand and acid was taken day and night. The record shows an average temperature of 128 deg. C. Since we had no gas regulator at hand the temperature varied from 136 to 120 deg. C.

The vase was subjected to the same test, excepting that the flame was applied directly to the vase and was therefore more difficult to maintain at a constant temperature. Especially was this true during the night when the gas pressure was stronger than during the day. Forty-two pounds of acid were used, since the test pieces had to be filled whenever the acid fell below half the capacity.

After the twelve weeks boiling, the fire was turned out and the test pieces were allowed to cool. They were then washed some thirty times with brush and water, placed in a drying oven, heated to 140 deg. C., cooled and washed again, and placed in the drying oven and heated to 140 deg. C. They were then placed in a jar containing fused calcium chloride. After 24 hours they were removed and weighed with the following results:

|                      | Grams Weight | Per Cent Loss |
|----------------------|--------------|---------------|
| Large crucible ..... | 932.854      | 0.0737        |
| Small crucible ..... | 192.000      | .....         |
| Vase .....           | 619.863      | 0.0981        |

One of the crucibles was then broken and reduced to a fine powder which was passed through a 16 mesh sieve and then through a 20 mesh sieve. One hundred of the largest grains remaining on the 20 mesh sieves were selected and thoroughly washed with distilled water, then dried to 110 deg. C., cooled in a desiccator, and weighed. The 100 selected grains weighed 180 grams.

They were transferred to a platinum crucible and treated with the acid mixture of 10 parts of concentrated nitric acid, plus 25 parts of concentrated sulphuric acid, plus 65 parts of water. The platinum crucible with the contents of the 100 grains and acids was placed on wire gauze on which a  $\frac{1}{8}$ -inch piece of asbestos  $1\frac{1}{2}$  inches in diameter was placed, and gently heated to boiling and held at that temperature until the water and nitric acid were vaporized and all sulphur fumes driven off. The whole operation took four hours. The crucible was then allowed to cool.

Water and nitric acid were again added and reheated to boiling and held for 10 minutes. The contents of the crucible were transferred to filter paper and washed thoroughly until the wash showed no acid reaction with blue litmus paper. It required about 1500 cc. of water to wash the grains free from acid. The grains were then dried in a drying oven to 110 deg. C. for five hours, then transferred to a desiccator and weighed. The weight of the grains was 179 grams, showing a loss of 0.56 per cent.

The grains were then transferred into the platinum crucible, which was previously heated and weighed, heated for 20 minutes and blasted for 10 minutes, then cooled in the desiccator. The loss shown was the same as before.

#### MICROGRAPHICAL EXAMINATION

Microscopic examinations were made of several samples by Professor Rolin B. Salisbury, geologist, University of Chicago, in order to determine the structure of the material and the composition of this stoneware after

it is burned. The writer has also made microscopic examinations of many samples.

The examinations have shown that in all cases, in the vitrified composition, the burning has produced fusion enough among the materials used in making the ware to develop a glass as in lavas. It could be noticed on the slides that this glass served as a binding material for the original grains which were not fused. These grains were bound together by the glass in very much the same way as are the crystals of some igneous rocks by the glassy uncrystallized parts of lava.

In physical composition, therefore, this stoneware is like a compact igneous rock which is but partly crystallized. The texture of the body is such as to indicate the possibilities of a high polish, so that spigots and stoppers could be ground to perfect joints; and the grain is so fine and even that clean-cut lettering and carving is possible. This has already been proven very satisfactorily.

In describing the material, Professor Salisbury notes that "under the microscope the material is seen to consist of grains of quartz, orthoclase, magnetite, and altered ferromagnesia mineral in a glassy ground mass. This ground mass was developed in the burning and is the result of the fusion of parts of the substance of which the body is composed.

"The pore space is about eleven per cent, but it should be noted that this is not the amount of space that will take up water, since the pores are in the glass and not accessible to water. The grains of quartz are angular (many) or rounded (fewer), apparently as they were before burning. They show little, if any sign of corrosion. The corners of the angular grains remain sharp, but there appears to be a very thin film of clear glass surrounding each.

"The feldspar grains, both orthoclase and plagioclase, are much altered on the outside, and grade into the ground mass without sharp demarkation. The smaller grains are altered throughout. Under the microscope the original grains are seen to be broken up into extremely fine fragments which are bound together by isotropic material. The effect of the heat appears first to have fractured the grains and then to have fused the material along the cracks. The little particles into which the feldspar is broken average about 0.002 mm. in diameter. There appears to be considerable kaolin, probably such as occurred in the original material from which the body was made.

"The ferromagnesia mineral is so much altered that its original character is not recognizable. But little of it is present. It is now altered to magnetite, surrounded by a brownish stain. It grades into the ground mass. The ground mass is of glass, filled with minute (.002 mm.) particles of quartz and feldspar. The union of the original particles seems to be as complete as in extrusive igneous rock which contains some glass."

It is interesting to consider the action which takes place between the alkaline earth and metals and oxides of silica, aluminium, and iron during the burning period.

When the fire is started, the hot air passes through the kiln warming up the green particles; and when the temperature of 110 deg. C. is reached inside the kiln, the hygroscopic moisture is forced to leave the green ware, and at a higher temperature the chemically combined moisture is driven off and oxidation follows. When this

is completed the bases and the silica and alumina combine in order to form various silicates. Naturally the base which has the lowest fusing point will fuse first, reacting with the finest grains of silica to form silicates, and then, in order, follow the next ones which have a higher melting point, until all the required eutectic mixture is in a sufficiently glutinous state to bind all the non-fused particles with a glassy bond to a dense body.

At first the feldspar substance in the body begins to soften; the fused feldspar is then attacking the clay substance while it is melting. However, the melting point of feldspar must not be misunderstood. Feldspar does not melt to a liquid and flow, but only softens and adheres to the more refractory particles. It is well known that the greater the proportion of undissolved material present in the mixture, the longer the ware will resist deformation. This fact is proven by the hard translucent porcelain, where the potter builds up his frame work with kaolin to insure the articles against becoming deformed within the heat limit.

#### COOLING AND ANNEALING

When the ware is sound and is vitrified to imperviousness, firing has ceased, and cooling and annealing commences. Annealing is a process of gradually cooling, which allows the silicates to settle and rearrange themselves in a condition of equilibrium. The annealing process is just as important in producing chemical ware as all of the processes in the manufacture of ceramics, to avoid molecular strain; yet it is the least understood by most manufacturers.

The importance of the annealing process is frequently to be seen in the case of glass tiles on sidewalks which have broken or disintegrated into powder. The reason lies in the fact that the glass, in the molten state, was poured into the steel mould and pressed. In this way the glass was chilled rapidly and the molecules on the surface rushed to adjust themselves. As a result, the glass becomes intensely solidified which prevents the molecules of the interior from rearranging and uniting. We can easily see that the glass is in a state of continual strain and is prevented from collapsing only by the intense rigidity of the exterior walls. As soon as the surface of the glass is scratched or broken, the whole tile breaks into pieces, sometimes making a violent noise. This is true with the stoneware also. If cooling is hurried too much, the ware will be brittle and invisible cracks will occur.

Cooling too slowly will cause too much of crystallization of the magna; therefore the cooling can proceed very fast until the temperature has fallen to red heat—say 1000 or 800 deg. C.—when freezing temperature of the eutectic has been reached; from then on cooling has to proceed very slowly, especially when the body is high in silica.

A very good idea of the formations and behavior of the silicates in the glass or ceramic bodies can be illustrated as follows:

Let us imagine a dancing hall, everything quiet; all persons present are comparatively motionless. Some may be in a standing position eagerly waiting for action, others seated. The orchestra commences to play. Every one hurriedly looks for his or her partner and then the couples dance around the hall in greatest order, one pair after the other. We never find that all the persons

commence to take action at once, but pair after pair until all are dancing, excepting the people on whom the catalytic action of the music has not taken effect.

As soon as the orchestra stops playing, the couples return to their places quietly and rearrange themselves orderly for the next action. Had there been any disturbance in the orchestra or among the dancing couples, the music naturally would have stopped at once and every pair would have parted in disorder, running unsettled in all directions. From this we learn that the orchestra had assumed the function of a catalyzer to produce action in the persons present in the dancing hall.

This is also true with the heat. When burning chemical stoneware, the heat is in reality not consumed; it only performs the action of forming the different silicates in order to produce vitrification in the ceramic bodies to make it impervious to moisture and acid. Thus we see that the function of the heat as a catalyzer is exactly the same as the music; every molecule of the heat is given up as soon as it has accomplished the required result.

## Portland Cement Construction for Chemical Works

By MAXIMILIAN TOCH

PORTLAND cement and the cements from which it has been derived have always shown a tendency to porosity and the necessity for either an added material or a coating in order to make it impervious has always been apparent. The Romans recognized the necessity for water-proofing Pozzuolan, the composition of which is quite similar to that of our Portland cement. Two thousand years ago they recommended the use of a small quantity of grease in order to water-proof their structures. Our rush to finish construction of all kinds demands the use not only of a water-proofing material but one which shall lubricate at the same time and overcome the shortcomings of the man at the mixer. For this purpose, there are two distinct types of water-proofing, both of which are patented, one practically composed of stearate of lime, free from glycerine, and the other composed of a glyceride of a fatty acid mixed with a colloid.

There are such vast quantities of nitre cake that are dumped into rivers and creeks near chemical works that the free sulphuric acid in the nitre cake has a tendency to dissolve out the Portland cement foundations of adjacent structures, and for this purpose, newer water-proofings for Portland cement have been invented which make the concrete relatively acid-proof, and after the forms have been removed, it has been found necessary to apply acid-proof coatings to such Portland cement foundations to prevent the disintegration from the acids that pollute the streams.

The scarcity of steel and the high price of lumber construction has done much for the progress in the building of Portland cement tanks for chemical works, the only feature being that special coatings have had to be devised, the kind depending upon the chemicals used. The thinner oils and many of the heavier oils cannot be stored in concrete unless the concrete is particularly dense and well finished, and even then it is not worth while taking a chance, but the application of an oil-

proof coating prevents concrete from being disintegrated. Even acids may now be stored in concrete tanks provided the tanks are finished with acid-proof brick linings which have been set in a heavy bituminous binding material.

The great advantage of a Portland cement tank for chemical works is that, assuming that it is built correctly, it will last forever, and that of course cannot be said of a wood or steel tank.

There are some chemical works that use large quantities of nitre cake. I know of one concern that built an entire storage shed of acid-proof concrete for storing nitre cake, and it has proved that concrete can be made impervious to acid, a feat which was regarded as impossible before the war.

### The Journal of the American Ceramic Society

A journal that is a pioneer in its field is always the subject of most careful scrutiny. When that field is representative of one of the oldest phases of human endeavor the cause for attention to the new publication is multiplied many fold. There has now appeared the first issue of the *Journal of the American Ceramic Society*, a monthly journal devoted to science and technique of the ceramic industries.

The American Ceramic Society belongs to the older family of scientific societies in the United States. The first meeting of the society, which was in reality a little family gathering of a small group of ceramic enthusiasts, was held in Columbus, Ohio, in February, 1899, and from that meeting grew the present organization due largely to the guiding genius of Prof. Edward Orton, Jr., of Ohio State University. The society is, therefore, in its twentieth year of vigorous and active life. The membership has increased from that early day until at present there are over a thousand enrolled.

In the American Ceramic Society, the term ceramic is synonymous with "silicate industries" and the interests and activities of the society include all branches of the clayware, glass and cement industries as well as enameled wares of all kinds and in addition other closely allied products are included, chief among which are abrasives, gypsum and lime. Few people realize the gigantic proportions of these ceramic industries. The products of the three major divisions alone (clayware, glass and cement) aggregate over \$400,000,000 per annum.

In the earlier days the society consisted of one main organization only. With increased activities and with enlargement in its scope of usefulness it became necessary to organize Local Sections for the following localities: St. Louis, Chicago, Central Ohio, Northern Ohio, West Virginia, Beaver, New England, New York State, New Jersey, and Pacific Coast.

Student Branches exist in Ohio State University, New York State, University of Illinois, Iowa State College.

The publication work of the society has, up to the present time, been confined to the issuing of its annual volume of *Transactions*. Twenty years ago this was a small, feeble effort, very creditable for the then existing state of our knowledge of the science of the silicate industries. This annual volume has shown continuous growth and the 1917 volume comprises 707 pages of

well-edited contributions. The American Ceramic Society's *Transactions* have been known for many years throughout the world as the standard reference books on the silicate industries.

This remarkable growth in strength and influence of the society has made it essential that periodical publication of the researches and other activities of the society members be undertaken and the monthly *Journal of the American Ceramic Society* is the logical result.

The first number is a very attractively prepared journal of seventy-two pages. It is well edited and well printed on good paper. The contents of the first number are as follows:

#### Editorials:

To the Public.

The Fuel Curtailment Orders.

The National Research Council.

Edward Orton, Jr.

#### Original Papers and Discussions:

Kaolin in Quebec—Keele.

Special Pots for the Melting of Optical Glass—Bleininger.

The Effect of Gravitation Upon the Drying of Ceramic Ware—Washburn.

Test of a Producer Gas-Fired Periodic Kiln—Harrop.

Notes on the Hydration of Anhydrite and Dead-Burned Gypsum—Gill.

Meetings of the Local Sections, American Ceramic Society.

The present officers of the society are: President, Homer F. Staley; vice-president, A. F. Greaves-Walker; treasurer, R. K. Hursh, and secretary, Charles F. Binns. Trustees: A. F. Hottinger, E. T. Montgomery, R. D. Landrum.

Membership in the society is open to anyone interested in any branch of the ceramic industries and application should be made to the society. All members receive the *Journal* gratis; to non-members the subscription price is \$6.00 per year (12 issues), payable to the secretary in advance.

### Graphite Supplies For 1918

About 30,000 tons of graphite suitable for crucible manufacture will be needed in 1918. If freight and market conditions and an improved labor situation favor the shipment of domestic graphite about 8000 tons of flake of crucible grade, exclusive of dust, can be marketed in this country in 1918, an increase of more than 100 per cent over the production in 1917. If the freight conditions that prevailed in the autumn of 1917 should recur the domestic production of No. 1 and No. 2 flake will hardly exceed 2500 tons. If the domestic production could be stimulated to its maximum capacity, reasonable assurance of a steady market given, and encouragement offered to new plants a production as high as 12,000 tons might be reached. The situation is more favorable with respect to noncrucible graphite. The requirements for 1918 will be between 28,000 and 31,000 tons, which may probably be supplied by domestic, artificial, and Mexican production. Amorphous graphite was produced in 1917 by five mines in Colorado, Michigan, Nevada, and Rhode Island. The production was 8301 tons, valued at \$73,481, compared with 2622 tons, valued at \$20,723, in 1916.



## Carborundum Refractories

### A Comparative Account of Silicon Carbide Refractories With Those in General Use—Great Improvement Made in Thermal Conductivity, Efficiency and Strength

By S. C. LINBARGER, B. S., CER. E.

EVER since its inception, one of the vital problems of the ceramic industry has been the question of suitable refractory materials, both for use in its own factories and as a product which will meet the demands of the other industries which require the highest grade of refractories. These materials must have sufficient strength under normal conditions to carry the weight of the structure of which they are an integral part and must, furthermore, have sufficient refractoriness to carry this same load under the extreme heat conditions to which they are subjected.

It has always been customary to regard heat insulation in a refractory material equally desirable with resistance to fusion, probably because these properties are intimately associated in the case of the common type of fire brick or sagger mix of the aluminous silicate type which are highly refractory and are such poor conductors of heat that in comparison with metallic substances they can safely be classed as heat insulators. However, only a superficial study of the problems involved in the burning of ware in saggars or muffle kilns reveals the fact that heat conductivity of the refractories used, besides being highly desirable, is a potent factor in the economical operation of the process.

For many years men connected with all branches of the clay working industry have been seeking a more effective means of burning clay products in a shorter time and with less fuel. Especially is this true and the need for it was never greater than at the present time when the vital needs of the country must be met with a maximum of fuel economy. Most of the efforts have been along the line of improving kiln design so that the maximum amount of heat is extracted from the gases of combustion before they pass into the stack. In most cases this is accomplished by passing the gases from the hot zone or chamber over ware in other zones which is at a much lower temperature and thereby gradually raise the temperature of the ware by the utilization of the sensible heat of the gases after they leave the combustion zone. All agree that when ware is being burned at a high maturing temperature one of the vital points of fuel economy is to get as much as is possible of the heat of the gases transferred from them to the ware.

In the pottery and allied industries where the ware is burned in saggars or by setting on shelves or bats a solution of this problem resolves itself into the proper selection and utilization of a refractory material which will more quickly and more easily absorb the heat from the surrounding gases and transmit and deliver it to the center of the bearing structure. The essential physical properties which govern the selection of the best refractory for this purpose are strength, specific heat,

thermal conductivity and emissivity. Of course in connection with these it must have the required refractoriness and be able to withstand the necessary handling without breakage.

The element of strength, both transverse and compressive, is one of the properties which is too often overlooked in the selection of the proper refractory material. By using a material of high mechanical strength, both under normal and heat conditions, not only is the loss by breakage materially reduced, but primarily the walls of the building material can be very much thinner, with the consequence that the heat is conducted to the ware much more readily, to say nothing of the saving in kiln space and the smaller amount of heat required to bring the building material up to the maturing temperature of the kiln.

The specific heat of the refractory is the important physical property required in calculating the number of thermal units that are really wasted in bringing the large mass of the supporting material from normal temperature up to the finishing temperature of the kiln. In some instances where the weight of the bats and saggars is equal to or more than the weight of the ware which it protects and supports, it means a considerable item in the burning costs.

As a concrete example of the exact factors involved in the transfer of heat from the hot kiln gases to the ware, let us consider the specific case of a plant which is burning ware in saggars, the saggars being set in stacks so arranged in the kiln that their entire peripheral surface is exposed to the kiln gases. The spaces between the sagger stacks can be assumed to be chimneys and the velocity of the gases through them will depend upon their size and shape and also upon the draft of the kiln. Assume the hypothesis:

1. That the turbulence is such as to make a fairly uniform temperature in the kiln at any point on one of a system of surfaces which is symmetrical about the gas passage; and

2. That the average temperature on these surfaces is the average of the temperature of the gases at ingress and egress.

It is evident that these hypotheses mean that the turbulence is controlled by some finite law that a graph indicating the temperature gradient through the kiln would be a straight line. These hypotheses hold fairly well if the motion of the gases is so slow as to make the turbulence negligible or if the motion of the hot gases is so great as to make the turbulence very great. The quantity of heat then that will pass through the walls of the supporting refractory medium in a given time and be delivered to the center of the saggars will depend upon the excess temperature of the gases over the

ware and the thermal conductivity of the refractory and will be a direct function of the emissivity of it.

When heat waves strike a body some of them are absorbed and some of them reflected unless the body be what is known as a "black body," in which case all of the heat rays are absorbed. All other bodies absorb a definite percentage of the heat waves which strike their surfaces and reflect the rest. The exact ratio of conduction and radiation being dependent upon the surface and the character of the body. This ratio for any material is what is known as the emissivity factor of that material. Under like conditions the same ratios hold true for the radiation of heat units from any solid body into a gaseous medium. The emissivity factor for any substance can then be determined experimentally by finding the radiation per second per unit surface area per degree difference in temperature. As the quantity of heat that will cross the boundary plane between the solid and the gas per unit time is dependent upon a factor other than the thermal conductivity of the solid, it is readily observed that the emissivity factor of the refractory which is usually neglected is an important consideration in the absorption of the greatest amount of the sensible heat from the gases which come in contact with it.

Crystallized silicon carbide or "carborundum" as it is most commonly called has long been recognized as having unique physical properties which make it peculiarly adaptable in the construction of highly refractory materials. However, up to the present time it has not had a very wide application in this field owing to its high price and also to the lack of sufficient quantities to supply other than the abrasive industry, which of course is its field of primary importance.

At the present time there are two types of crystallized carborundum refractories which have been highly developed. The first type which goes under the trade names of "Refrax" and "Silfrax," depending upon whether the crystallization of the aggregate is large or small, is made according to patents which in general cover the silification of mixtures of carbon and silicon carbide or carbon forms and their subsequent conversion into carborundum by subjecting the carbon to silicon containing vapors at the heat of the electric furnace. The carbon is converted into carbide of silicon forming a dense interstitial binder or matrix between the crystals. Of course there are many modifications of this process but the essential characteristic of this type of refractory is that the final products obtained are pure silicon carbide.

The other type which is known as "Carbofrax" is the type most generally applicable for use in the ceramic industries. It is made by bonding graded crystallized carbide of silicon grains with various percentages of a mixture of special refractory clays or other bonding substances.

When bonded with even a high percentage of clay binder, brick which contains carborundum gives very great refractory values. However, since the refractoriness of a conglomerate refractory mass is a direct function of the amount and character of the least refractory constituent, it is recognized that the ideal condition to be obtained is that the amount of binding material used be the least consistent with the requisite

strength; and that the vitrification temperature of the binder be as high as is commercially practical. Mixtures of grits and methods of bonding are employed which insure a very dense body of low porosity with but a minute percentage of refractory clay binder and at the same time allow the manufacture of large and intricate shapes.

Experimentation has shown that crystalline silicon carbide forms at 1840 deg. C. and dissociates at 2240 deg. C. into its elements, the silicon being volatilized and the carbon remaining as graphite. No softening or fusing occurs below the dissociation temperature which is shown by the sharp and perfect forms of graphite pseudomorphs or skeletons which are left when silicon carbide dissociates. This is in direct contrast to most other refractories such as silica, chrome, and fireclay brick which soften at a temperature several hundred degrees lower than their fusion point.

Fig. 1 shows the emissivity curves of several common refractories. The curves for this factor were accurately

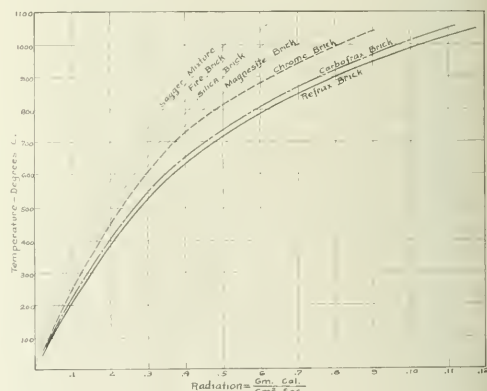


FIG. 1.—HEAT EMISSIVITY CURVES

plotted from results obtained by very complex experimental methods which are too cumbersome to describe in this paper. It will be noted that the emissivity of both classes of crystallized carborundum brick is much higher than either magnesite or chrome brick and almost double that of clay brick at a temperature of 200 deg. C. and higher.

| Material        | Specific Heat | Thermal Conductivity | Compressive Strength, Lb. per Sq. In. |
|-----------------|---------------|----------------------|---------------------------------------|
| Fire brick..... | 0.192         | 0.0034               | 1,050                                 |
| Sagger mix..... | 0.187         | 0.0033               | 1,340                                 |
| Magnesite.....  | 0.220         | 0.0071               | 4,800                                 |
| Chrome.....     | 0.174         | 0.0067               | 3,900                                 |
| Refrax.....     | 0.162         | 0.0275               | 12,500                                |
| Carbofrax.....  | 0.180         | 0.0243               | 14,700                                |
| Silica.....     | 0.191         | 0.0020               | 2,300                                 |

Table I shows the results of some tests made on the most common types of refractory materials. The specimens tested were selected at random as being representative of the average product of that particular class of refractory. No attempt was made to compare different brands of the same material.

A comparison of the thermal conductivities of the materials reveals the fact that the carbofrax brick will conduct about three times as much heat as magnesite, seven times as much as the sagger mix and twelve times as much as a silica brick in the same period of time.

Fig. 2 graphically represents the relative efficiencies of various refractory materials as obtained by using the values of specific heat, thermal conductivity and emissivity in the formula for the law governing the transmission of heat from a gas to the interior of a solid body. The figure is arbitrarily based with the abscissae representing relative efficiencies while the ordinates give difference of temperature. A study of the results demonstrates that the materials with a high emissivity factor and high coefficient of heat conductivity show several times the efficiency of those with correspondingly lower values with the same thickness of wall. Compressive tests of the materials show that the carborundum refractories have a load-carrying capacity over ten times as great as the sagger mixture under normal temperatures. Under heat conditions this ratio is considerably increased because there is absolutely no softening of this class of material at 1350 deg. C. while the sagger mix at the same temperature shows a deforma-

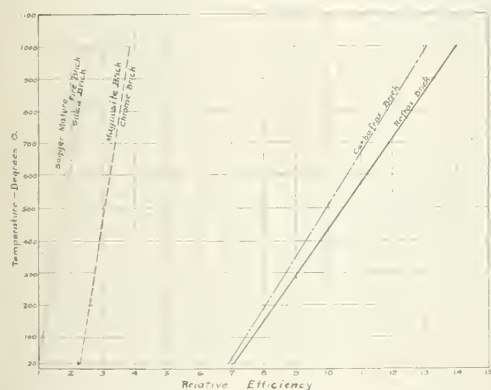


FIG. 2

RELATIVE EFFICIENCIES OF REFRACTORY MATERIALS

tion with a load of 50 pounds per square inch. In fact, blocks of bonded SiC are used as bearing blocks in making load tests on refractories at high temperatures. It would then be possible to use refractories for supporting ware in kilns with walls one-tenth as thick as is ordinarily used with the aluminous silicate type of refractories. Since the amount of heat transmitted by a solid is inversely proportional to its thickness, the efficiency already demonstrated by high thermal conductivity and emissivity would be multiplied by ten.

Aside from the importance of fuel economy, high thermal conductivity and heat capacity of crystallized carborundum impart to refractories made from it the property of withstanding the most sudden temperature changes because any variance in the temperature of the surface is quickly communicated to the whole mass and the heat is rapidly dissipated. Thus, the molecular work resulting from it is uniform and refractory shapes of this type can be subjected to the most sudden variations of temperature without being cracked or disintegrated.

As silicon carbide is not subject to any molecular changes being formed at 1850 deg. C. in a crystalline state and has an extremely low coefficient of expansion, no porous structure is necessary and a high density can

therefore be obtained. This is not possible with most refractories since they contain ingredients which have one or more allotropic forms and must be made open and porous to successfully withstand the internal stresses. The low coefficient of expansion and high density of carborundum brick permit the construction of solid structures in places where the leakage of heat and gases through cracks in the walls due to alternate contraction and expansion is a detriment to the successful operation of the process.

In an effort to obtain the complete combustion of a fuel there is a growing tendency to increase the temperature of the fireboxes or furnaces. Ordinary firebrick, even of the best grade, fuses under the high temperatures developed and is attacked by the fluid ashes of the coal. This fluid ash which so violently attacks fireclay brick forms a brownish coating or glaze over the exposed portion of the carborundum brick which is unattacked by any additional fluid ash which is formed in the firebox. Owing to their extreme hardness this type of brick does not suffer from deterioration as the common refractories do when struck by the tools of the fireman during the process of cleaning the fires.

Carborundum is manufactured by passing an electric current through a mixture of sawdust, sand and coke in a long rectangular resistance furnace. By the utilization of an enormous amount of electric energy, the central portion of the furnace is brought up to about 2200 deg. C. at which temperature the silica is volatilized. One molecule of silicon combines with one of carbon forming a core of pure crystallized SiC or silicon carbide between the electrodes in opposite ends of the furnace. Immediately surrounding this is a zone of the amorphous variety of carborundum which is commercially known as firesand. Chemically it is a mixture of several silico-carbides which vary in composition from  $\text{Si}_2\text{C}_2\text{O}$  to  $\text{Si}_3\text{C}_3\text{O}$ . This represents a partial reduction of silica by carbon or a solid solution of silicon carbide in silica.

This material is also highly refractory but owing to its lower heat of formation and lack of definite crystalline structure it is not as stable under extremely high temperature as the crystalline variety. However, it has a wide application in places where a higher degree of refractoriness is required than can be obtained in the best grade of fireclay brick.

Finely ground firesand when mixed with a bonding material such as kaolin or high grade plastic fireclay, makes a refractory which can be moulded in place or plastered over the surface of a lower grade refractory to protect it from the cutting action of impinging flames. Owing to the fact that even the intense reducing heat of an oil flame does not cause any modification of the firesand, it has come to be a recognized material for the linings of brass furnaces of all types. It is also used as a protective coating for the brick work of furnaces, bag and baffle walls and the walls of potter's kilns. For this work it is mixed with water and sodium silicate, and oftentimes a small amount of clay to increase the adhesion, and applied to the walls in a slip condition. Refractory materials made of mixtures containing silicon carbide are now being used in various capacities in the ceramic as well as the metallurgical industries.





## From A to Z With the Exhibitors

**THE BALTIMORE COOPERAGE CO.**—A complete line of miniature tanks which are exact reproductions of the larger sizes made for the chemical, drug and acid trade.

**GENERAL FIRE EXTINGUISHER COMPANY**—Grinnell sprinkler head in actual operation in a glass house or cabinet. At intervals a fire will be started on the floor of this cabinet which automatically opens the sprinkler head and releases the water, putting the fire out. Sprinkler supervisory service will also be illustrated. In charge of exhibit: FRANK V. SACKETT, HOWARD E. BRANCH.

**GEORGIA CHAMBER OF COMMERCE**—Through the courtesy of T. Poole Maynard, this organization will have a representative at his booth to give information regarding Georgia mineral products.

**GORDON ENGINEERING CORPORATION**—Two standard Gordon dryers, type B- and F-2. Since our entry into the war this company has developed a type of dryer for primers, detonators, explosives, etc., in use in Government arsenals. In charge of exhibit: HAROLD B. HARVEY.

**GLENS FALLS MACHINE WORKS.** Demonstration of a rotary sulphur burner; the Wood's machine, used as a save-all or washer for gun cotton as well as wood pulp; and a consistency regulator for regulating consistency of any kind of pulp. In charge of exhibit: JAMES H. HAINES, FRED CHAFFEE and M. G. TIBBETTS.

**EMIL GREINAR COMPANY.** A display of chemical glassware manufactured in the company's own plant in New York City, including accurate graduated glassware, burettes, pipettes, flasks, cylinders, thermometers, hydrometers and apparatus for gas analysis. In charge of exhibit: FREDERICK KRAISSE, PAUL TODTSCHINDER.

**GROCH CENTRIFUGAL FLOTATION, LTD.** A working model illustrating this system of flotation as applied to the treatment of valuable mineral-bearing ores. This system and appliances have been developed since the war. In charge of exhibit: FRANK GROCH, L. W. LEDYARD, W. E. SIMPSON.

**GUERNSEY EARTHENWARE COMPANY**—A complete line of chemical laboratory porcelain consisting of crucibles, casseroles, evaporating dishes, dry pots, concentric rings, desiccator plates, funnels, combusted boats, mortars and pestles, porous plates, retorts, etc. In charge of exhibits: ALLEN L. GOULDING.

**HANOVIA CHEMICAL AND MANUFACTURING COMPANY**—Apparatus for heat measurement and control; thermoelectric pyrometers, new model indicators and recorders, thermocouples, protecting tubes, central control and signal-system units, standardization equipment. Electric resistance thermometers, indicators, testing sets, thermometer bulbs. Electric furnaces and Impervite porcelain. The new developments of this company since we entered the war are new model pyrometer indicators and recorders and Impervite porcelain. In charge of exhibit: R. W. NEWCOMB.

**HARDIDGE CONICAL MILL COMPANY**—Working model of a Hardinge mill together with a large size glass model to show the interior workings. There will also be on exhibit a sample of Hardinge WE lining which

permits lining a mill without exposing any of the bolt heads to the action of the balls. In charge of exhibit: E. W. LAWLER.

**HAUSER-STANDER TANK COMPANY**—A standard rectangular tank with sides and bottom cut out to show the method of rodding and bracing. A special type of crystallizing tank will also be shown with a few staves removed to show the interior arrangement. In charge of exhibit: S. HAUSER, JR.

**HAYNES STELLITE COMPANY**—Standard bar stock and bits, lathe tools of the arc-welded type, followed and inserted two milling cutters, end mill and some miscellaneous lathe tools. There will also be exhibited some products of the instrument and cutlery department, including surgical and dental implements, table knives, forks, spoons, ladles, pocket knives, mirrors, saws, etc. The new developments of this company since the war began consist of surgical instruments furnished the War Department. In charge of exhibit: ROE L. JOHNSON, H. S. DUNHAM, T. C. EDWARDS.

**HELLENIC CHEMICAL & COLOR COMPANY, INC.**—A line of dyestuffs, dry colors and some chemicals. This company has developed several colors since the war began, which were formerly imported from Germany. In charge of exhibit: MESSRS. WILLIAMS AND HAWTOW.

**FRANK HEMINGWAY, INC.**—Dyestuffs, mill supply specialties, intermediates and chemicals. This exhibit will feature a new stripping compound and a perfect substitute for cream of tartar for all but edible purposes. In charge of exhibit: T. F. O'KEEFE, H. H. FOSTER, H. ARNERUSTER.

**S. S. HEPWORTH COMPANY**—Belt-driven and electric centrifugal machine in operation. The electric type is particularly adapted to chemical plants requiring a machine of large capacity but not running continuously. This machine has been developed for special service since the entry of our country into the war. In charge of exhibit: BRUNO C. LECHLER, CHARLES A. ALCOTT, FOSTER E. BABBITT.

**HERCULES ENGINEERING CORPORATION**—Illustrations of a general line of chemical apparatus and the Hercules chlorine compressor. In charge of exhibit: R. D. KEHOE.

**THE HERCULES POWDER CO.** Samples of chemical products such as pyroxylin solutions, water-proof belt cement, lacquers, aeroplane dopes, together with samples of kelp from which solvents and potash are extracted; samples of potash fertilizer. On Wednesday morning motion pictures and slides of the harvesting of kelp and views of the plant where it is refined will be shown. The products resulting from the treatment of kelp have all been developed since the beginning of the war. In charge of exhibit: G. C. O'BRIEN, A. B. DEAN, J. H. RILE, J. P. BUTLER and C. A. HIGGINS.

**HEROLD CHINA AND POTTERY COMPANY.** Demonstration of porcelain ware, American made, showing how it will withstand heat and sudden changes of temperature.

**HOLLY PNEUMATIC SYSTEMS, INC.**—Pneumatic conveying installation with a suction dust filter, demonstrating the possibility of conveying pneumatically and economically all material from units not over 1½ in. in diameter down to material as fine as dust. Experiments are under way on a large scale for the recovery of pot

ash from cement kiln gases. In charge of exhibit: L. F. HOLLY.

HOOKE ELECTROCHEMICAL COMPANY—Chlorine products. In charge of exhibit: Representatives from New York office and Niagara Falls plant.

HOSKINS MANUFACTURING COMPANY—Electric laboratory furnaces and hotplates; laboratory triangles, gauze and tongs; electric tool furnaces; recording and indicating pyrometers, thermocouples and thermocouple protecting tubes. In charge of exhibit: CHARLES S. KINNISON.

HOWES PUBLISHING COMPANY—An exhibit devoted to the American Dyestuff Reporter. In charge of exhibit: A. P. HOWES.

HUFF ELECTROSTATIC SEPARATOR COMPANY—An electrostatic separating machine or the treatment of ores of graphite, zinc, tungsten, manganese, copper, molybdenum. During the exposition the machine will be in operation on the treatment of various materials which may be submitted for preparation or concentration. In charge of exhibit: H. B. JOHNSON.

HUNTER DRY KILN COMPANY—Compounds of different kinds of rubber dried and processed by the Hunter system. Photographs of various installations. In charge of exhibit: HARRY HUNTER, OREN M. RAGSDALE, ARTHUR B. STONEX.

F. C. HUYCK & SONS. This company has specialized in woolen cloths for mechanical purposes, particularly the paper making trade, and in conjunction with the development of the chemical and dye industry in this country during the war have turned their knowledge of wool and machinery to the supply of woolen filter cloths which they will exhibit, showing the various stages in the production, and the materials from which they are made. In charge of exhibit: H. M. ASHBY, F. J. MCGOVERN.

IMPERIAL COLOR WORKS, INC.—An exhibit in conjunction with IMPERIAL DYEWOOD COMPANY and JOHN H. HEALD & COMPANY, INC. Dry and pulp colors and dyewood extracts; dry colors for the paint, printing ink, leather, textile and kindred trades; pulp colors for surface coating and paper mills; special dyes for wool dyeing and producing army khaki. In charge of exhibit: MESSRS. JACK AND CONSTANTINE.

IMPERIAL DYEWOOD COMPANY, INC. A display of dyestuffs in paste and crystal form showing the crude tropical woods from which the dyestuffs are made. In charge of exhibit: ROBERT CONSTANTINE.

INDEPENDENT CHEMICAL COMPANY. A display of heavy chemicals and acids which they manufacture for several companies. In charge of exhibit: O. CRISPENE, T. SULLIVAN.

INDUSTRIAL FILTRATION CORPORATION. Vacuum filters. In charge of exhibit: WM. H. HARDER, JR., W. H. LOUGHREY, HENRY B. FABER, H. W. CONRAD, J. R. HESS. INNIS, SPEIDEN & Co. Display of chemicals and allied products.

JACQUES WOLF & COMPANY—Chemical specialties for the textile industry and dyestuffs. The following products have been developed subsequent to the war: Hydro-sulphites, sulphur blacks, chrome black, gallant. In charge of exhibit: DR. ALFRED PFISTER, S. F. CARTER, C. E. HESSLING, WALTER DEUBLE, C. G. BOOTH.

JANNEY, STEINMETZ & COMPANY—Cold-drawn steel shapes suitable for the chemical industry, and hot-drawn high pressure cylinders for various gases and liquids under pressure. In charge of exhibit: N. W. SCHLATER.

JEWELL POLAR COMPANY—Steam, gas and electrically operated stills. A steam still in operation in connection with the Crane Company's adjoining exhibit. In charge of exhibits: A. C. JEWELL.

KALBFLEISCH CORPORATION—Mineral acids, metallic salts, paper makers' chemicals, alum, lacquers and thinners. The special features of the exhibit are permanganate of soda, sulphate of soda, anhydrous for standardizing dyes and colors. Among the products not made by this company prior to the war are permanganate of soda, alum, satin white and boro phosphate crystals. In charge of exhibit: V. P. DAVIS.

KALBPERRY CORPORATION, ENGINEERS—The investigation and determination of chemical investments. The design and operation of chemical plants. A recent development is a method of all-masonry construction for concentrating, Glover, Gay Lussac and denitrating towers and similar chemical construction in which leakage due to cracking has been obviated. In charge of exhibit: P. W. WEBSTER.

KEWAUNEE MANUFACTURING COMPANY—Chemical laboratory desks of various types; apparatus cabinets, fume hood, special plumbing fixtures and accessories for chemical laboratories. In charge of exhibit: O. T. LOUIS, CHARLES RESS, R. A. HANNA.

KEYSTONE MINERALS COMPANY—Rotten stone, Keystone black filler, velvet filler, mineral black. The new features of the exhibit are a fine grade of rotten stone and a new mineral black. In charge of exhibit: J. T. AND F. J. O'BRIEN.

KING CHEMICAL COMPANY—Sulphuric and nitric acids and sulphur dioxide. The latter was originally imported by this company from Belgium but it has since developed a plant for the manufacture of this chemical. In charge of exhibit: O. CRESPELERS.

MAURICE A. KNIGHT—General line of acid proof chemical stoneware apparatus. In charge of exhibit: MAURICE A. KNIGHT, CHARLES N. DENNISON.

H. KOPPERS COMPANY—Illustration of the essential features of the Koppers by-product coke ovens. Samples of coke and other fire products. The particular development of this country since the war began is the construction of a number of toluol recovery plants. In charge of exhibit: H. C. KIRKPATRICK.

LEEDS & NORTHRUP COMPANY—Electrical apparatus and equipment for the heat-treatment of steel, including the automatic signalling system used in connection with recording temperatures. Apparatus developed since the war began includes a portable a.c. galvanometer and an apparatus for the rapid electrolytic determination of carbon in steel. In charge of exhibit: E. A. KEELER, E. B. ESTABROOK.

ARTHUR D. LITTLE, INC.: Examples of the application of chemical engineering and chemistry to industries. In charge of exhibit: H. E. HOWE.

WALTER E. LUMMUS CO.: Continuous concentrating still, periodic column still, dissolving apparatus, "metro-lift," tower scrubber. Present activities practically



limited to war requirements, providing apparatus for solvent recovery, stills for benzol, toluol and naphtha, acetone and alcohol apparatus, evaporators and stills for products for poisonous gases. In charge of exhibit: C. F. TEARS, G. S. HOUGHLAND, J. T. STONE, E. W. BARTRAM.

EMIL E. LUNGWITZ: Kelly filter press, hand-operated and fitted with the latest automatic locks. A special Kelly filter press made of solid copper will be exhibited to show that these presses can be made of different metals for specific purposes. In charge of exhibit: C. L. BRYDEN, H. L. DICK, PAUL BARTELT.

LUZERNE RUBBER CO.: Hard-rubber specialties and standard goods. Items of interest to the chemical trade are hard-rubber piping, fittings, buckets, etc., for the handling of chemicals, acids and alkali solutions. In charge of exhibit: C. D. WILSON, HARRY E. CASE.

MACBETH-EVANS GLASS CO.: Chemical glassware, including beakers, flasks of various shapes and sizes, Petri dishes and covers, watch glasses, crystallizing dishes, funnels and moist chambers. In charge of exhibit: H. P. FULLER, J. W. HARVEY.

MARDEN, ORTH & HASTINGS CORPORATION: A full line of the dyestuffs and intermediates manufactured at the various plants of the company, samples of heavy chemicals and special brands of animal, vegetable, oriental and fish oils. Considerable attention attaches to this exhibit on account of the fact that many of the products were first developed in America by this concern.

MATHIESON ALKALI WORKS: Exhibiting jointly with Arnold, Hoffman & Company, Inc. Bleaching powder, liquid chlorine, caustic soda, soda ash, bicarbonate of soda and modified sodas.

T. POOLE MAYNARD: Geological, industrial and chemical engineering. Representing the Georgia Potash & Chemical Company, the Georgia Mineral Products Company, the Interstate Clay Company, the Southern Ball Clay Company. The Georgia Chamber of Commerce is at Mr. Maynard's booth, by courtesy. In charge of booth: T. POOLE MAYNARD, V. R. WAITE.

FREDERICK MAYWALD. Consulting chemist.

MENDLESON CORPORATION: Chlorinated lime, caustic soda and lye. There will also be on exhibition some of the small amber glass tubes each containing one gram of chlorinated lime, which are supplied to soldiers in the trenches for sterilizing drinking water. Each tube will sterilize a barrelful or field waterbagful of water and make it safe to drink. In charge of exhibit: J. M. STEMLER, P. E. ERIKSON, J. E. SAMMOND.

MERCK & Co.: Medicinal chemicals and chemical reagents for use by physicians and in chemical laboratories. The company's works at Rahway, N. J., have been considerably extended since the war began in 1914 and have produced for the first time a number of new products such as carbolic acid, salicylates, hydroquinone, aniline, nitrobenzine, acetanilid, acetphenetidin, resorcin, paranitraline, phenolsulphonates, betanaphthol compounds, paraphenylenediamine.

METALS DISINTEGRATING COMPANY. Exhibiting samples of zinc dust, aluminum dust, tin dust and aluminium paint. Since the United States entered the war this company has developed on a large scale a process for the production of aluminium powder suitable for military purposes. In charge of exhibit: S. G. SCHATZBERG, W. H. NAUGLE.

B. MIFFLIN HOOD BRICK CO. Chemical stoneware of a hundred different sizes and shapes specially manufactured and adapted to acid-proof masonry construction. This material is suitable for the construction of towers, scrubbing towers, oxidation and denitration, also concentrators, Glover and Gay Lussac towers and tanks; spiral rings for tower packing. In charge of exhibit: B. MIFFLIN HOOD, J. J. NEER, G. BERGEN FORD.

MINE & SMELTER SUPPLY COMPANY. Massco clay goods and refractories made from Colorado clays; McCool pulverizer used for pulverizing assayed samples, chemicals, coal, etc.; Samson laboratory crusher; Lindsay low-pressure oil burner. One of the features of the exhibit will be a small Wilfley concentrating table, used for concentrating ores and for recovering and separating such industrial wastes as brass, copper and alloys. In charge of exhibit: J. SHEDDEN, E. S. TOMPKINS.

MINER-EDGAR COMPANY. Chemical products from the plant of the Seaboard Chemical Company and the Alcohol Products Company, manufacturers of wood alcohol and acetate solvents for special industries. Washed and floated clays for ceramic and paper uses. The chemical part of this company's business has been largely developed since 1914. In charge of exhibit: R. H. FRENCH.

MONARCH MANUFACTURING WORKS, INC. Stoneware sulphuric acid and chamber sprays in operation. The entire exhibit includes sprays in general, lead stop valves, lead check valves, lead syphons, furnace oil burners. The stoneware spray for nitric acid has been produced since this country entered the war. In charge of exhibit: T. W. MURPHY.

MONONGAHELA VALLEY TRACTION COMPANY. An exhibit of all products manufactured or mined in the company's territory; full information on bituminous coal, the most important resource; samples of glass-sand and coal pyrites. The West Virginia Geological Survey will contribute its library of state publications. The cities of Fairmount, Clarksburg, Parkersburg and Marietta will each contribute samples of their manufacturing industries. Important developments since the beginning of the war are the manufacture of gas and ammonium sulphate by the Lynn process, and the manufacture of sulphuric acid from coal pyrites. In charge of exhibit: For WEST VIRGINIA GEOLOGICAL SURVEY, PROFESSOR KRAK; For MONONGAHELA VALLEY TRACTION COMPANY, FRNACIS MCQUILLIN.

MULTI METAL COMPANY INC. Screens for bolting, sifting and filtration, made of brass, copper, bronze, phosphor-bronze, Monel metal, perforated metals. Pulmosan safety devices for the protection of workmen exposed to polluted air or poisonous fumes; helmets, breathing masks and respirators. In charge of exhibit: FREDERICK STERN.

NASH ENGINEERING COMPANY. Hydroturbine air compressors and vacuum pumps; Jennings turbine vacuum and low-pressure boiler feed pumps. The display will include pumps in actual operation. Special machinery devised to meet contingencies brought on by the war includes a successful chlorine compressor which, however, will not be exhibited. In charge of exhibit: IRVING C. JENNINGS, HOWARD M. WYLIE, G. B. WRIGHT.

NASSAU VALVE & PUMP COMPANY, INC. Acid-resisting valves, fittings, centrifugal pumps and castings for

hot or cold corrosive liquids, especially sulphuric acid and sulphates. In charge of exhibit: RAYMOND K. SNAVELY.

**NATIONAL ANILINE & CHEMICAL COMPANY, INC.** Exhibit of dyeings of American and German colors, both having previously been subjected to the same tests of scouring, pulling and exposure to light and weather. About 130 National dyes; a full range of intermediates; a quantity of dyed material and dyed garments of all descriptions: special dyeings of alizarine and indigo; a dyeing unit of a colorist's laboratory in which dyeings will be made on request. While the greater part of the dye exhibit represents developments since the war, special attention is called to alizarine and indigo. In charge of exhibit: L. J. MATOS.

**NEW JERSEY ZINC COMPANY.** An exhibit of products including various brands of zinc oxide, lithopone, ochre, zinc dust, zinc chlorine, (both liquid and fused), sulphuric and muriatic acids, as well as the newly developed U. S. P. zinc oxide now being produced in commercial quantities for the first time in the history of the country. Zinc cadmium and barium salts will be on exhibition, as well as samples of the finish which can be secured by the use of zinc pigments in paints. Among the metal products of the company are spelter, spiegel-eisen, gold and silver bullion. The application of zinc dust in sherardizing and protective coating work will be illustrated. The production of U. S. P. zinc oxide for making pharmaceutical preparations is a new development, the output of the company at the present time being figured in ton per day. In charge of exhibit: W. H. HENDRICKS.

**NIAGARA ELECTRO CHEMICAL COMPANY.** Cyanides exhibited in the booth of the ROESSLER & HASSLACHER CHEMICAL COMPANY.

**NICHOLS COPPER COMPANY.** Copper sulphate crystals; refined copper wire bar; pyramids illustrating the metallurgy of copper, containing ores, concentrates, blister, refined copper, silver and gold; pyramids of packages of Triangle brand blue vitriol; samples of gold, silver, selenium, copper oxide and nickel sulphate. In charge of exhibit: W. C. BENNETT and G. P. HITCHCOCK.

**NITROGEN PRODUCTS COMPANY.** Exhibiting jointly with ARNOLD, HOFFMAN COMPANY, INC. Sodium cyanide, lump and powdered, red and yellow prussiate of soda and anhydrous ammonia.

**NORTON COMPANY.** Comprehensive display of alundum and crystalline refractories and laboratory wear. Demonstrations will be made on a laboratory scale of physical and chemical properties of these materials. Apparatus of various kinds will be in operation. In charge of exhibit: HAROLD R. SAVAGE.

**OHIO POTTERY COMPANY.** Chemical porcelain ware, including beakers, casseroles, crucibles, evaporating dishes, filter plates, funnels, mortars, spatulas, etc. In charge of exhibit: GEORGE E. and C. D. FRAUNFELTER.

**OLIVER CONTINUOUS FILTER CO.** A small filter with accessories operating on cement dust from a potash recovery plant to show how every step on a continuous and automatic filter takes place; other types and accessories are also shown. Many types of filter have been manufactured since we entered the war for handling products not made in United States before the war. In

charge of exhibit: E. L. OLIVER, R. G. WALKER, L. GAZARIAN.

**ONTARIO BUREAU OF MINES.** Ores and minerals from the Province of Ontario, together with chemical and metallurgical products of the same. Of special interest will be the exhibit of nickel and molybdenum ore, together with their metallurgical products. A wide range of metallic and non-metallic minerals will display the extent of the resources of Ontario. In charge of exhibit: W. K. MCNEILL, W. R. ROGERS, THOMAS W. GIBSON.

**ORGANIC SALT & ACID COMPANY.** Chemical products comprising salicylic acid, salol, sodium salicylate, acetyl-salicylic acid, acetanilid, tri-phenyl phosphate.

**PAGE STEEL & WIRE COMPANY.** Samples of wire fabric for factory enclosures and fences. One sample will be made of American ingot wire and another of "Copperweld" wire. Copper-clad wire for electrical transmission has been widely used during the last year in the construction of cantonments. In charge of exhibit: W. T. KYLE.

**PALO COMPANY.** Laboratory supplies, including Durieux filter paper, Hess-Ives tint photometer, Despatch electric ovens, Link automatic water stills, Rhotanium. In charge of exhibit: M. J. SEAVY.

**THE PRAUDLER CO.** A display of acid-resisting, glass-lined steel tanks. A feature of this exhibit is a tank that has been used for boiling inorganic acid for one year and is still in good condition. In charge of exhibit: W. E. FOSTER.

**PHILADELPHIA QUARTZ COMPANY.** An exhibit showing the different forms of silicate of soda. In charge of exhibit: JAMES G. VAIL.

**PHILADELPHIA TEXTILE MACHINERY COMPANY.** Model of Proctor dryer for the drying of paints, chemicals, etc.; also samples of various paint colors and other materials being dried in the Proctor dryer. In charge of exhibit: W. R. MURRAY.

**PNEUMERCATOR COMPANY.** Various types of pneumatic equipment to demonstrate the method of measuring the weight, volume or depth of liquids contained in tanks. In charge of exhibit: WILLIAM THOMAS.

**POWDERED COAL ENGINEERING & EQUIPMENT COMPANY.** In actual operation, a small unit for burning powdered coal. The equipment is applicable to the firing of low-pressure and high-pressure heating boilers of the kind commonly used in apartment houses and small office buildings. It also lends itself to application in metallurgical work, forging, heat treating, etc. In charge of exhibit: H. B. PRUDEN.

**PRECISION INSTRUMENT COMPANY.** Apparatus for regulating and measuring the efficiency of combustion: CO<sub>2</sub> recorder; draft gages; flue gas analyzers. The particular feature of the exhibit will be an air speed indicator for aeroplanes which has been developed and produced since we entered the war. In charge of exhibit: ABRAM T. BALDWIN, C. E. CONWAY, and Messrs. VINCENT and GILSON.

**PRODUCT SALES COMPANY.** Industrial minerals such as acid tower quartz, feldspar, ground silica, barytes, crude and ground soapstone. A special feature of the exhibit will be chemically pure asbestos for laboratory use. In charge of exhibit: HENRY N. HANNA, Miss N. M. VOLOSHEV.

# CHEMICAL & METALLURGICAL ENGINEERING

A consolidation of ELECTROCHEMICAL & METALLURGICAL INDUSTRY and IRON & STEEL MAGAZINE

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### Germany in The Melting Pot

THE weak spot in Germany's armor at the beginning of the war was in her shortage of the non-ferrous metals. To ameliorate this a national inventory of all the metals was made from which a sort of military registration was evolved of candle sticks, church bells, chandeliers, copper roofs, brass pipes, bronze statues, token coins, etc., with the varying classifications as to their military essentiality. All Belgian articles were given class 1-A immediately. The Hohenzollern and Hapsburg bronze statues were placed at the other end of the line in class 5-G. All others were given intermediate classifications.

All went well during the early days of the draft. The calling out of class 1-A was a jubilant assemblage. Early successes brought in many tons of scrap. The work of reclaiming on the battle-fields became an important factor in the supplies of copper, tin, nickel, etc. However, in spite of all this, the disbursements were so enormous that the draft gradually passed on into the deferred classes. The great classic statues of Schiller and Goethe lost their dignity and their value as scrap-metal soared so high that the labors of the sculptors were petty items on the German account books.

With the cremation of the Schillers and Goethes in the foundry cupolas, for work in the front lines, the wonder soon grew as to why the Friedrichs der Grosses and Wilhelms did not leave their park pedestals, for surely poets were not of greater need at the front than the Deutschland-über-Alles commanders of yore. Indignation among the enlightened population of Germany grew to such an extent that three bronze Hohenzollerns enlisted at Berlin, three more at Cologne, two from Munich and one each from several towns along the Rhine, to save their fame.

Another interesting feature in the German metal situation is the exalted uses of iron. The military honor crosses of the rusty metal have no more intrinsic material value that the lucky horseshoe of legendary fame. Not satisfied in limiting the iron "toting" to the soldiers, Germany has instituted iron coinage. The fractional mark coins are no longer of copper and nickel but are forgings of Siemens-Martin steel, the nobility of the non-corroding ferro-silicons being too high for the office. Thus the embossed German eagle has been elected to join the Schillers, Goethes, Wilhelms and Friedrichs of the metal world in their new vocations.

The really satisfactory thing about this is the clear evidence afforded of the lack of metals on the other side of the Rhine. The fate of the monuments and coins typifies Germany—all are in the melting pot.



## Our Preeminence in Metal Production

IN VIEW of the important part played by metals in the prosecution of the war, it is a significant fact that neither Germany nor Austria holds first rank in the production of a single vital metal. The Allies, on the other hand, not only have the advantage of the United States' leadership in base-metal production, but they also control the output of the precious metals. Taking the latter first, we find that Great Britain controls over 60 per cent of the output of gold, through the mines of South Africa and Australia. The United States leads in silver production. Russia is the most important source of platinum, so necessary for making heavy acids for explosives; and while that unfortunate country may not be a comforting asset just now, there is abundant opportunity to capitalize her metal resources if we proceed in the right way.

Among the base metals, the United States takes first place in the production of lead, copper and zinc, all useful in the manufacture of small ammunition. In iron and steel, also, we have normally led the other nations, producing about 40 per cent of the world's total. This has been of incalculable value in the making of ships, guns and projectiles, and in the tremendous amount of construction that has been under way. Aluminium for light alloys used in aeroplane construction is of vital importance, and here again the United States is the fortunate leader in production. With nickel available in large quantities from the mines of Canada and refineries of our own country, and tungsten from Colorado and California, we have the basis for alloy steels of the first importance. Indeed it would be difficult to find a brighter galaxy, and it is safe to say that no other nation is so favored. The advantage which it represents cannot be adequately estimated because so many factors enter into our ultimate success; but if a careful analysis could be made and reliable values assigned to our various advantages we venture the belief that our preëminence in metal production would stand near the head of the list.

## War Minerals Bill Ready for Signature

WE WERE advised yesterday that the War Minerals bill, which has been pending for so many months, had finally passed both houses of Congress and awaited the President's signature. It is exceedingly unfortunate that there has been so much delay in passing this needed legislation, for there is no doubt that a great deal of work has been postponed until the attitude of the Government could be determined. There were features in the House bill, however, which became the subject of so much controversy that it soon became apparent that delay was inevitable. The price-fixing and licensing features were the subject of attack, as was also the amount of the revolving fund which had to be provided for operations under the terms of the bill. When the House bill went to the Senate, that body struck out everything following the enacting clause, which is an effective parliamentary procedure in amending a bill, and then added ten sections of its own drafting. The price-fixing feature went by the board; the amount of the revolving fund was changed from \$10,000,000 back to the original \$50,-

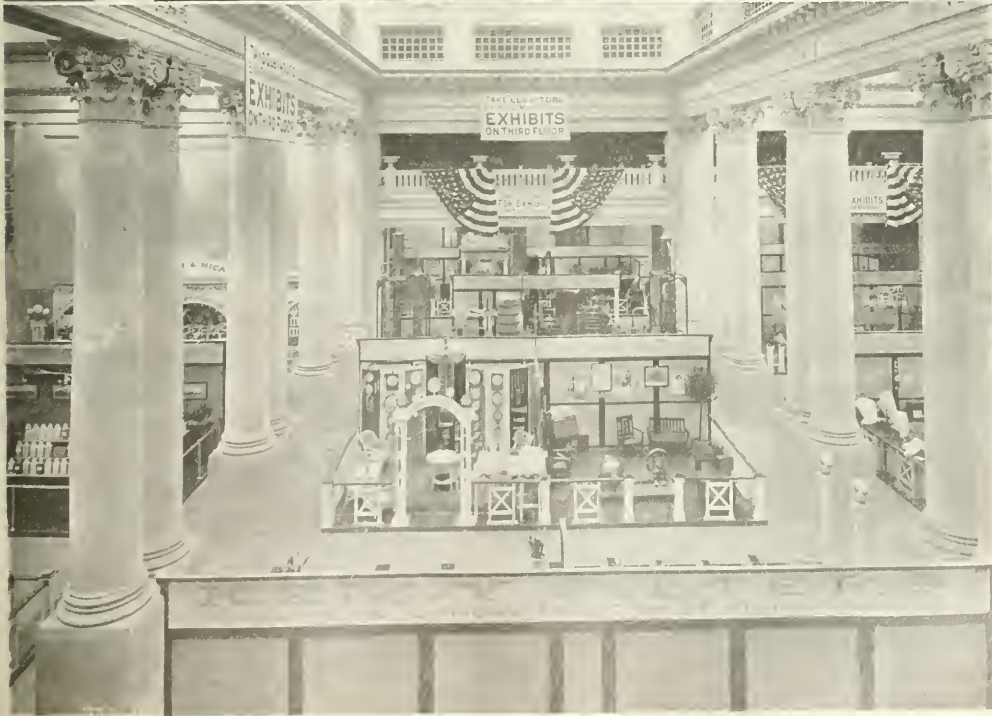
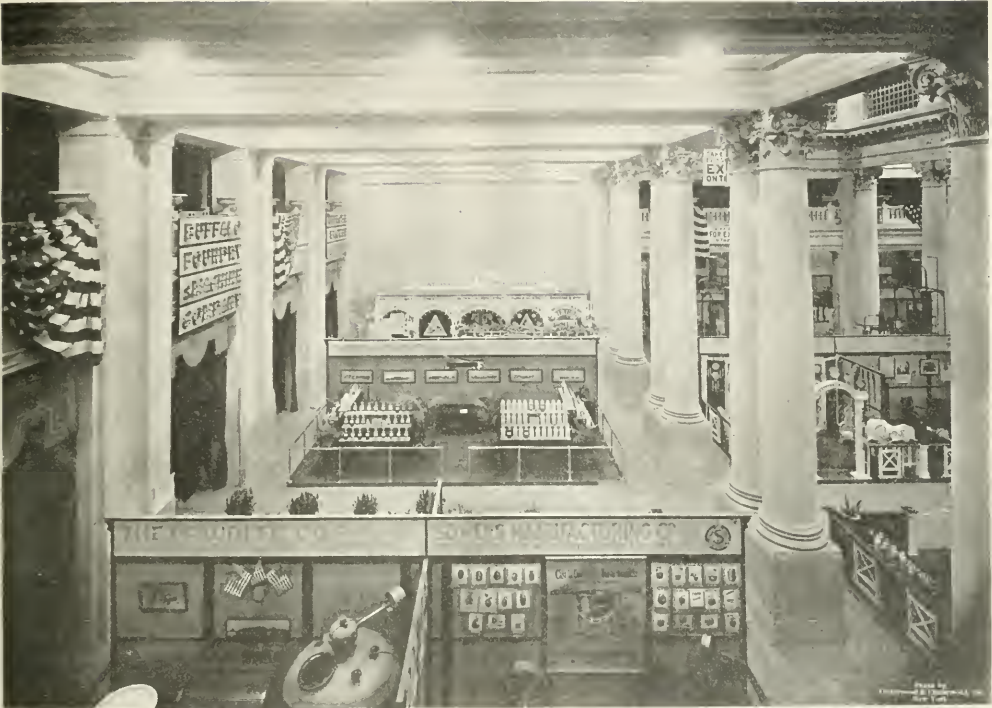
000,000; provision was made for a system of contracts between producers and the Government; and in general a better bill was drawn up than was conceived by the House. The Senate was more conservative, and yet the hope is expressed that its bill will be quite as effective as the House intended its own should be.

In brief, the bill authorizes the President to enter into contracts for the production or purchase of certain ores, minerals and metallurgical products, and to use, allocate or sell them in the interest of the national security and defense and the successful prosecution of the war. In order that producers shall feel properly safeguarded and warranted in producing materials for sale under the terms of the bill, it is provided that contracts for purchase may cover a period of two years after the end of the war, but not longer. The President is further authorized to requisition and take over the materials under consideration, as well as mines and metallurgical works capable of producing them, and to operate such mines or works in any manner he may deem best. Just compensation is to be made to the parties from whom the mines or works are taken, and provision is made for determining what that just compensation may be, in case agreement cannot be reached without resort to litigation. We fancy that prospect of having to litigate to determine a settlement will not make a strong appeal to those whose mines or works may be taken over.

The sum of \$50,000,000 is appropriated as a revolving fund with which to carry out the objects of the bill. Corporations may be formed by the President to facilitate the purpose of the bill, and the United States may subscribe their capital stock from the revolving fund. In such event the President would designate the directors of the corporations, who would hold and vote the capital stock for the exclusive benefit of the United States.

Only a brief survey is required to see that enormous powers are vested in the President, and it is presumed that he will designate certain individuals to exercise these powers for him. Indeed the bill provides for the designation of officers or agents who shall act for the President. In the appointment of these agents will lie the ultimate success of the measure. This was one of the points that caused much discussion over the original House bill which provided for a Minerals Administrator comparable to the Food and Fuel Administrators. The present bill does not contemplate such an official, but there are others that must be appointed, and in their selection the President will have an opportunity to display good judgment. The mining and metallurgical industries have developed some excellent executives and there should be no difficulty in finding good men to fill such places as may be created.

The minerals and metals in the interest of which the bill is drawn comprise a formidable array beginning with antimony and ending with zirconium. In order to meet emergencies, provision is made to include "such other rare or unusual elements" as to which there may be a present or prospective shortage. It remains to be seen whether the assumed need for the bill exists. We believe from many reports received at this office that some federal authority is needed to insure adequate production of certain materials, and in our opinion the desired result should be accomplished by this bill.





## Sidelights on the Exposition

THE Chemical Catalog Co. of 1 Madison Avenue, N. Y., has a busy exhibit on the main floor, and although it has only copies of a single book to show, the visiting public displays a lively interest in it. The purpose of the book is to tell, in convenient form, the names of all the makers and producers of chemicals and chemical apparatus in the country. Publication began in 1916 with an issue of 8500 copies of a book of 205 pages each. In 1918, 10,200 copies were printed and each volume contains 578 pages. The chemical names of materials are given and, as far as possible, trade names are also set forth, while underneath each product or thing indicated is recorded the name and address of every producer in the United States, so far as diligent search may bring it out. Proper cross references serve the purpose of added elucidation and avoid unnecessary repetition as well.

The book is loaned without charge for one year to professors, consulting chemists, chemical engineers, works managers, manufacturers and others comprising a list of such as may have actual use for it as an aid in buying. To others it is sold at the price of five dollars per copy.

A list of technical books is given at the end with descriptive digests and information as to author, publisher and price.

\* \* \*

That big Hough patent nitrator which the Buffalo Foundry people show is only their medium size, says Mr. Hough. If used for TNT it takes a charge of 25,000 lb. of mixed acid and 2500 lb. of toluene. The 2500 lb. of toluene is run into the acid in 30 minutes and owing to the spray arrangement and the circulation of the acid, every pound of the hydrocarbon meets 3500 lb. of acid. The volume of the nitrating body keeps down the temperature while the flow of the whole over the cooling coils provides that a variation of not over one-half deg. C. takes place between the point of contact of hydrocarbon and acid and the center of the machine.

As the toluene is injected in, the temperature rapidly rises to 50 deg. C. and it is maintained at this point by control of water in the coils, thus producing dinitrotoluene in the first instance—i.e., in the initial half-hour. The cooling water is then shut off and the heat of the reaction carries the temperature up to the "cooking stage," or about 110 deg. C. In three hours more, or within three and one-half hours from beginning the operation, the process is complete and there is produced about 5300 lb. of TNT or, roughly, 85 per cent of the theoretical yield.

Water is sucked and not driven through the cooling coils and litmus indicators are placed at the outlet of each. Then, if a coil leaks, the acid gets into the water and shows itself immediately, whereupon the offending coil may be shut off and no serious harm is done. If the water were driven through the coils and a coil should leak, the water would go into the acid and play the deuce with the reaction. And there would be no indicator to tell the story. Perfectly reasonable, but rather clever, we think. When the machine is set up it is insulated with three inches of asbestos.

The temperature control enables a great variety of

nitrating processes to be carried on. There is no stuffing box or bearing within the machine. And over 30,000,000 lb. of TNT have been successfully made in several of these apparatus within the past two and one-half years.

\* \* \*

The General Electric Co. has on exhibition some handsome specimens of ferro-zirconium and ferro-chrome-zirconium which they have lately developed with gratifying success.

They show also as a novelty a water japan which should cheer the hearts of the fire insurance men. The japanning ovens of many manufacturing establishments are their danger spots for it is here that fires may get beyond control of the sprinkler system. To this is added the explosion hazard of great quantities of vaporized hydrocarbon or carbohydrate japan solvent mixed with air. The new japan base is a colloid in which the disperse phase is an asphalt and the continuous phase an animal or vegetable oil. By reaction with an alkali a portion of the continuous phase is saponified, whereupon the soap functions as an emulsifying agent. Then, on addition of water, an emulsion is produced in which water is the continuous phase and the japan base the disperse phase. Droplets of the latter are negatively charged and adhere to the positively charged metal in a practically anhydrous state. After baking, the japan is adherent and insoluble in water. Before baking, the japan may be applied with a brush or articles may be dipped in the emulsion, heated to the boiling point of water to give it the proper consistency.

\* \* \*

We have yet to learn of anybody who has worked with Dr. Allen Rogers who did not grow to like him. The Pratt Institute boys who have taken his course in industrial chemistry hover about him whenever they get a chance after they have graduated, and men who have been associated with him on committees or otherwise are likely to respond, if asked to name a good man to undertake a task that requires reasonableness and intelligence and the avoidance of trouble, "Can't you get Allen Rogers?" Now he is in the army in the Chemical Warfare Service, with the slim waist and springy step that they all seem to achieve; and he has a gold leaf on each shoulder, because he is Major Rogers withal, connected with the Relations Section. His name is on the top of a paper given out by the Chemical Warfare Service and under it are recorded the following activities:

The allocation of enlisted men after the war.

Answers to appeal for advice from chemists and from manufacturers.

Transfers of men in the service on indefinite furlough, which is divided under two heads: those not formerly employed where they are needed and those that were.

Deferred classification of chemists and skilled workmen.

Any one of these problems looks to us like a man's job, and if Uncle Sam had come around to ask our advice as to a good man to look after these things; somebody with a heart and a sense of humor and a head that doesn't swell up or run away or topple over, we should have said, as we have said before; "Can't you get Allen Rogers?"



## The Ferro-Alloys\*

A Brief Description of the Manufacture, Properties and Uses of the Alloys of Iron with Manganese, Silicon, Aluminium, Chromium, Tungsten, Molybdenum, Vanadium, Titanium, Boron, and Uranium

By J. W. RICHARDS†

**A**LARGE industry has grown up within the last fifty years, most of it within the last twenty-five years, which furnishes to steel makers alloys of iron with some of the rarer metals, in order to introduce these rare metals into steel. Such alloys are known as ferro-alloys, because they all contain iron (ferrum); some of them, however, contain more of the rare metal than iron. They were originally made in crucibles, cupolas or blast-furnaces, but are now made principally in electric furnaces, and their manufacture is one of the principal electric-furnace industries.

They are of great importance to the steel industry. The steel maker uses them for one of two purposes: (1) As reagents to take oxygen out of melted steel and thus insure sound solid casting (ferromanganese, ferrosilicon, ferroaluminium); or (2) to put into the steel a small or large percentage of the rare metal (ferromanganese, ferrochromium, ferrotungsten, ferromolybdenum, ferrovanadium, ferrotitanium, ferrouranium, ferroboron).

Let us discuss briefly these two uses. Melted steel, just before taking from the furnace, always contains some oxygen dissolved in it (like the dissolved gas in charged soda water). If this is not removed, the casting made is more or less unsound from cavities or blowholes. The addition of a small amount of a metal with a high affinity for oxygen removes this element and makes the casting sound. Manganese (1 per cent or less) is the cheapest and most generally used reagent for accomplishing this; silicon (2 per cent or less) is more powerful but also more expensive, and is often used to supplement the action of manganese; aluminium (0.1 per cent or less) is still more powerful and still more expensive, and is used in very small quantities as a final addition to complete the action of the manganese and silicon. All steel makers use one, two or all three of these reagents; manganese and silicon in the form of ferro-alloys, aluminium more often as the pure metal, but ferro-aluminium is sometimes used.

The second use is to make special steels, that is, steels containing such quantities of the rare metal as give to them properties different from plain carbon steels deoxidized by manganese, silicon or aluminium. Thus we may make manganese steel by putting in 12 to 14 per cent of manganese making a very tough, hard steel such as is used in mining and grinding machinery, burglar-proof vaults etc.; chromium (2 to 4 per cent) makes a very hard tool steel; tungsten (15 to 25 per cent) makes high-speed tool steel, which cuts iron while

red-hot; molybdenum (6 to 10 per cent) has powers similar to tungsten, and is also used in steel for lining large guns. Vanadium ( $\frac{1}{10}$  to  $\frac{1}{2}$  per cent) makes very strong steel which resists shock extremely well, as when used for automobile axles; titanium, uranium and boron impart valuable properties not so easily described. Every one of these materials is used for producing some specific result which is not produced by any other; sometimes combinations of two, three or four are used in one steel, producing a particular combination of special properties for some special purpose. Some of these materials cost \$5 per pound, and the special steels produced cost up to \$2.50 per pound, but their particularly valuable properties justify the expense. The value of these special steels to the industries, and particularly for military purposes, is very great, so great that the supply of ferro-alloys for their manufacture is an important factor in winning the war.

### FERROMANGANESE

This is the oldest of the ferro-alloys. Its manufacture was begun about 50 years ago. It was first made in crucibles, has for a long time been made in blast-furnaces, but is now being produced in many places in electric furnaces. It is made with 30 to 85 per cent manganese, 3 to 5 per cent carbon, a little silicon and the rest iron. The rich grades, 75 to 85 per cent, are preferred by the steel maker, but they require rich manganese ores for their manufacture. The United States has very little rich manganese ore, but large quantities of low-grade ores; one of the present burdens of the steel maker is to use low-grade ferromanganese, in order that we may not have to use ships for importing the high-grade ores from Brazil.

The usual manufacture in blast-furnaces is wasteful of both fuel and manganese; the furnace must be run hot and slowly, with very hot blast in order to reduce the manganese oxide ore as completely as possible and not waste manganese in the slag. Yet, in spite of all efforts, from 15 to 25 per cent of the manganese going into the furnace escapes reduction and is lost in the slag. This waste of fuel and manganese has led to the use of the electric furnace, in which fuel is required only as a chemical reagent and not to produce heat, thus saving about two-thirds the fuel requirements of the blast furnace, while the higher temperature available causes the extraction of manganese to reach 90 per cent, i.e., slag losses to be down to 10 per cent or less. Against these economies must be set the considerable expense for electric power and the smaller scale on which the furnaces run. At the present high prices of coke and manganese ore, and in view of the scarcity of manganese and the high price of ferro-

\*A paper read at the Fourth National Exposition of Chemical Industries, New York, Sept. 27, 1918.

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manganese, the electric ferromanganese industry is able to exist and make large profits. Whether it can do so when normal conditions return, after the war, is questionable; it is to be hoped that it will be able to do so, because of the economy which it undoubtedly possesses in regard to fuel and manganese.

Steel producers use ferromanganese particularly for making the low carbon or soft steels, because they can thus introduce the required manganese for de-oxidation without putting in considerable carbon. For higher carbon steels spiegeleisen (15 to 20 per cent manganese), a cheap blast-furnace alloy, can be used, and is being used at present wherever practicable, in order to save ferromanganese. The best practice with either spiegeleisen or ferromanganese is to melt them in a small electric furnace, and tap from it the required weight to be added to the heat of steel. The melted alloy mixes quicker with and reacts more actively upon the melted steel, while less of it is necessary because less is oxidized by the furnace gases. The saving in manganese by the use of the electrically-melted ferro is alone sufficient to justify the expense of melting it in an electric furnace, while better and more homogeneous steel is produced.

#### FERROSILICON

This alloy may run 15 to 90 per cent silicon, but the most commonly used is the 50 per cent grade. It is made from ordinary silica (quartz or sand), reduced by carbon in the presence of iron ore or scrap iron. The blast furnace is able to make only the lowest (15 per cent) grade, because silica is exceptionally difficult to reduce, and under conditions which would reduce 99 per cent of the iron ore in a furnace, or 75 per cent of the manganese ore, only 15 to 20 per cent of the silica present can be reduced, and only a low-grade silicon alloy produced. The higher grades must all be produced in the electric furnace.

The raw materials are ordinary silica, the most abundant metallic oxide on the earth's surface, iron ore or scrap iron (iron or steel turnings or punchings), and coke. Electric furnaces up to 10,000 hp. have been operated on ferrosilicon (50 per cent grade). At the high temperature required, a not inconsiderable proportion of the reduced silicon vaporizes, and burns outside the furnace to a white silica smoke. This can be largely prevented by skillful furnace supervision. In normal times, the 50 per cent alloy sells at \$45 to \$50 per ton, which is a low price for an alloy so difficult to produce.

Steel producers use ferrosilicon principally for the great activity with which the silicon removes dissolved oxygen from the steel. It is about four times as active as manganese in thus reducing blow-holes and producing sound castings. It is usual, however, to use manganese first, to do the bulk of the deoxidation, and silicon afterwards to finish up the reaction more completely. It is particularly useful in making sound steel castings which are cast into their ultimate form and do not have to be worked into shape, because a slight excess of silicon may make the steel hard to forge or roll, whereas an excess of manganese does not have so bad an effect on the working qualities. A particular kind of steel called silicon steel carries 1 to 2 per cent of

silicon and yet forges well; this would be classed as a special steel.

The ferrosilicon industry has attained large proportions in countries where electric power is cheap, particularly therefore in Switzerland, the French Alps, Norway, Canada, and parts of the United States. Under present conditions it is even profitably run where electric power is relatively dear, as at Anniston, Ala., and Baltimore, Md. It is a large, interesting, and rapidly growing industry.

#### FERRO-ALUMINIUM

This alloy, with 10 to 20 per cent of aluminium, was made in the electric furnace and used in considerable quantity in steel about 1885-88, but was displaced by pure aluminium as the latter became cheaper. Aluminium is about seven times as powerful as silicon and twenty-eight times as strong as manganese in acting upon the oxygen dissolved in steel; therefore only minute quantities are necessary, say one ounce up to a maximum of one pound of aluminium per ton of steel. Its use gives the finishing touch to the de-oxidation of the steel.

About 1885 the Cowles brothers, operating the first large electrical furnaces run in America, at Lockport, New York, made and sold considerable quantities of ferroaluminium, selling the aluminium in it at the rate of about \$2 per pound, while the pure metal was then costing \$5. When, a few years later, pure aluminium sold for 50 cents per pound, the steel makers turned to using the pure metal instead of ferroaluminium, and at the present time aluminium is so used in practically every steel works in the world.

There seems to me a distinct opportunity for makers of ferro-alloys to revive the manufacture and sale of ferroaluminium. Such great advances have been made in the construction and operation of large electric furnaces since 1890, and so much experience has been had in reducing the difficult oxides to ferro-alloys, that the production of 50 per cent ferroaluminium at say \$100 per ton may be a distinct electric furnace possibility. That would furnish the contained aluminium at about 10 cents per pound, as against 30 cents for the commercial aluminium now used. The alloy should be broken up small before using, and thrown in the runner or on the bottom of the ladle, in order that the melted steel may quickly dissolve it as it runs into the ladle.

Such ferroaluminium would require bauxite with iron ore or scrap iron, for its manufacture, but there are large deposits of low-grade bauxite rich in iron, in Southern France, which could be reduced directly to the alloy without any additions, and thus furnish very cheap raw material for the operation.

In conclusion, ferroaluminium is not now being made, but its electric furnace production is a real possibility.

#### FERROCHROMIUM

Ferrochromium is used for making what is familiarly but erroneously called "chrome steel." It makes steel exceedingly hard. Very hard cutting tools, and armor plates to resist projectiles, are made of it. Only 2 to 4 per cent of chromium may be used.

Several grades are made in the electric furnace, depending on the per cent of chromium (25 to 75), and

the content of carbon (2 to 8 per cent). This alloy takes up carbon so actively in the furnace that it has to be treated subsequently to remove the carbon down to what can be endured by the steel into which it is introduced.

The raw material for its manufacture is chromite, an oxide ore of both chromium and iron. If this is mixed with carbon and smelted in the electric furnace it reduces directly to ferrochromium alloy (often misnamed "ferro-chrome"), and highly saturated with carbon (6 to 10 per cent). Steel makers want lower carbon than this, so the alloy is re-melted with more chromite in another furnace, and the excess of carbon oxidized out. The low-carbon alloy sells for 2 to 3 times the price of the high-carbon crude material.

The cutting off of importations of high-grade chromite ore from Asia Minor has led to intense prospecting in the United States. Fair material has been found in many places, and at present our country is nearly independent of foreign sources of the ore.

#### FERROTUNGSTEN

Tungsten (also called wolfram) imparts curious and valuable properties to steel. A small amount (2 to 5 per cent) has been used for half a century or more, to make the steel self-hardening; that is, a tool of this steel need only be let cool in the air, and it becomes hard without the ordinary quenching or chilling operation. Larger proportions (10 to 25 per cent) make a steel which stays hard even when red hot. A tool of this material can be run so fast on a lathe, for instance, that it gets red-hot from the friction and work, yet keeps hard and keeps on cutting. It is called high-speed tool steel, and its use alone has more than doubled the output capacity of the machine shops of the world.

The ore used in either wolframite, a black oxide of iron and tungsten, or scheelite, a white oxide of calcium and tungsten. It is found in considerable quantities in Colorado, and some other Western States, and imports of this ore have not been necessary during the war. In this respect we are much more favorably situated than the European nations. A plentiful supply of tungsten ore may indeed be regarded as a large factor in the production of cannon and fire-arms and all kinds of machinery, and therefore a considerable factor in winning the war.

#### FERROMOLYBDENUM

Molybdenum has only recently come into large use in steel. Its action being somewhat similar to that of tungsten, scarcity of the latter metal, particularly in Europe, has led to the manufacture of ferromolybdenum on a comparatively large scale.

The ores are widely distributed but not very plentiful. Molybdenum sulphide, molybdenite, looks almost exactly like shiny graphite but it is a shade lighter in color and nearly twice as heavy. It occurs usually as flakes in granite rock and might easily be mistaken for graphite. Lead molybdate, wulfenite, is a compound of lead and molybdenum oxides, a very prettily crystallized yellow to red mineral in thin square plates. It occurs abundantly in a few lead mines in the West. It is usually first treated to extract its lead, and the residue then worked for molybdenum. The sulphide

used to be roasted to molybdenum oxides, and this reduced by carbon in the presence of iron ore or scrap iron in an electric furnace. It is now smelted directly in the electric furnace with carbon and a large excess of lime along with iron ore or scrap iron. Ferro with 50 to 60 per cent of molybdenum is tapped from the furnace like other ferro-alloys, but with molybdenum up to 80 per cent the alloy has such a high melting point that it cannot be tapped out without freezing; it is necessary to make a furnace full of this alloy and then let the furnace cool down and take it apart, taking out a large mass of solidified alloy; the furnace is then rebuilt.

The large use of molybdenum in steel has been so recent that not much has been made public about it. Rumor says that the large German guns which bombarded Liege (the "Black Berthas") were lined with molybdenum steel (6 to 7 per cent) to increase their resistance to erosion. It seems certain that Germany drew considerable supplies of molybdenite from Norway to compensate for shortage of tungsten for high-speed tool steel. Parts of guns, gun carriages, motors, automobiles, have also been made of molybdenum steel of most excellent quality. Canada has been especially active in the manufacture of ferromolybdenum steel, most of which is exported to Europe. This alloy is therefore another valuable war material.

#### FERROVANADIUM

Without vanadium the modern automobile or auto-truck would be a much weaker machine. When steel is desired to withstand the heaviest shocks and vibration, nothing is quite so effective as adding vanadium. This is another comparatively rare metal, found principally in the radium ores of Colorado and as a black sulphide on the highlands of Peru. The canary yellow Colorado ore is treated for radium, and the residues for vanadium and uranium. The U. S. Government (Bureau of Mines) operated this process for the radium supply. The black ore of Peru is rich and unusual; it is a sulphide with some asphaltic matter, and it is roasted to the condition of iron-vanadium oxide before reduction. The oxides are best reduced by metallic aluminium. This is the well-known thermit (Goldschmidt) method of reduction. Electric furnace reduction by carbon is not advantageous because of the large amount of carbon taken up by the alloy; powdered silicon is therefore put into the charge as the reducing agent, together with iron, lime and fluorspar, and then a 30 to 40 per cent vanadium alloy is obtained with seldom over 1 per cent of carbon, a very desirable composition (R. M. Keeney).

Only small amounts of vanadium are necessary to improve steel; 0.1 to 0.4 per cent are the usual quantities. This is fortunate because the vanadium costs \$5 per pound and over. Metallurgists suspect that part of the improvement of the steel may be due to the vanadium combining with and removing nitrogen dissolved in the melted steel. This is probably true, yet some advantage undoubtedly must be ascribed to the final vanadium content in the steel; both avenues of improvement function. Steels thus treated are unusually resistant to shock and alternate stresses, making them very useful for axles, cranks, piston-rods, and such severe service.



## FERROTITANIUM

Titanium is an abundant element in nature. It occurs in immense amounts as a double oxide of titanium and iron, known as ilmenite, or titanic iron ore. This ore can be reduced directly by carbon in electric furnaces to ferrotitanium. The reduction proceeds easier if some aluminium is put in as a reducing agent, but this is expensive and unnecessary. The alloy running 15 to 25 per cent titanium is sold for use in steel as a refining agent to remove oxygen and nitrogen. Thousands of tons of steel for rails has been thus treated, the tests showing considerable improvement in the mechanical properties by the use of quite small amounts (0.10 to 0.20 per cent) of titanium.

## FERROBORON

This is another alloy whose valuable qualities have not yet been entirely determined. Boron is the metallic base of borax, which is a sodiumboron oxide. Borax is very difficult to reduce to the metallic state. Another raw material, not so abundant, is colemanite, containing lime and boron oxide. Many attempts have been made, none very successfully, to reduce this with iron oxide to ferroboration. The American Borax Co. offered a prize, for several years, for a process which would accomplish this. Boron oxide occurs rarely in nature, but it can also be manufactured from borax and colemanite. When the oxide is obtained, this can be combined with iron oxide and the resultant boron-iron compound reduced by carbon in the electric furnace to ferroboration. Small quantities of this alloy have thus been manufactured.

Experiments on steel have shown that ferroboration acts somewhat similarly to ferrovanadium. Experiments in France showed remarkably strong and tough steels were thus made, using 0.5 to 2 per cent of boron. The results have not been properly followed up, partly on account of the difficulty in getting ferroboration; no one, as yet, has taken up its regular manufacture and steel makers can hardly be blamed in these stirring times for not having as yet thoroughly explored its possibilities as an addition to steel.

## FERRO-URANIUM

This is the latest of the ferro-alloys to enter the lists. Uranium is a very heavy and, chemically, very active element. It is found very scarcely as a black oxide, the mineral pitchblende—the mineral in which radium was first discovered. It is found more abundantly in the Colorado radium ore, a bright yellow oxide and silicate of vanadium, uranium and lime. After extracting the radium and vanadium, the uranium remains in the residue as a by-product, usually as a soda-uranium compound. This is treated so that uranium oxide is obtained, and this can be reduced by carbon in an electric furnace in the presence of iron ore or scrap iron, to ferrouanium (30 to 60 per cent). The recovery of uranium is not high (50 to 70 per cent) the rest being lost in the slag. Mr. R. M. Keeney has recently described these processes in detail, for the first time in the August *Bulletin* of the American Institute of Mining Engineers.

The results of tests showing the influence of uranium on steel are not yet completely known. Some firms have

claimed for it wonderful strengthening power and resistance to shock. The subject is still receiving expert attention from steel makers, and valuable results are confidently expected.

## CONCLUSION

The ferro-alloys are exceedingly important materials to the steel maker, either in the making of ordinary steel or for producing special alloy steels. They are indispensable to the steel industry. They are important factors in producing both ordinary and fine steels, and therefore in winning the war. The country well supplied with them has a great advantage over the country in which they are scarce. They are deserving of all the expert attention which they are receiving from the War Industries Board, the steel makers, and the economists. The possession by the United States of large supplies and resources in the ferro-alloy line, may be one of the important factors in determining the quick ending of the war.

## Spelter Specifications

The percentage of impurities in the four commercial grades of spelter have been compiled by C. E. Siebenthal of the U. S. Geological Survey from the following specifications:

1. Am. Soc. Test. Mat. Proc.; vol. 11, pp. 147-149, 1911: Adopted August 21, 1911.
2. Am. Soc. Test. Mat. Proc.; vol. 16, pp. 583-589, 1917. vol. 17, pp. 180-181, 1917.
3. Navy Department Specifications, 47Zld, June 1, 1917.
4. U. S. Army, Ordnance Department Specifications, Revised March 7, 1918.
5. Navy Department Specifications, 47Zlb, Nov. 1, 1913.
6. New York Metal Exchange Specifications; American Metal Market, August 31, 1916.

| Specification           | Zinc, min. | Cadmium, max. | Iron, max. | Lead, max. | Cadmium, iron, lead, max. sum | Aluminium, max. | Other elements |
|-------------------------|------------|---------------|------------|------------|-------------------------------|-----------------|----------------|
| <b>A. High Grade</b>    |            |               |            |            |                               |                 |                |
| 1                       | 99.85      | 0.05          | 0.03       | 0.07       | 0.10                          | 0               | 0              |
| 2                       | 99.85      | 0.07          | 0.03       | 0.07       | 0.10                          | 0               | 0              |
| 3                       | 99.85      | 0.05          | 0.03       | 0.07       | 0.10                          | 0               | 0              |
| 4                       | 99.50      | 0.50          | 0.03       | 0.10       | 0.50                          | 0               | 0              |
| <b>B. Intermediate</b>  |            |               |            |            |                               |                 |                |
| 1                       | 99.35      | 0.50          | 0.03       | 0.20       | 0.50                          | 0               | Tr             |
| 2                       | 99.35      | 0.50          | 0.03       | 0.20       | 0.50                          | 0               | Tr             |
| 3                       | 99.35      | 0.50          | 0.03       | 0.20       | 0.50                          | 0               | Tr             |
| 4                       | 99.35      | 0.50          | 0.03       | 0.25       | 0.65                          | 0               | Tr             |
| <b>C. Brass Special</b> |            |               |            |            |                               |                 |                |
| 1                       | 98.00      | 0.75          | 0.04       | 0.75       | 1.20                          | 0               | Tr             |
| 2                       | 98.00      | 0.50          | 0.03       | 0.60       | 1.00                          | 0               | Tr             |
| 3                       | 98.00      | 0.75          | 0.04       | 0.80       | 1.25                          | 0               | Tr             |
| 4                       | 98.00      | 0.75          | 0.08       | 1.00       | 1.50                          | Tr              | Tr             |
| 5                       | 98.00      | 0.75          | 0.08       | 1.00       | 1.50                          | Tr              | Tr             |
| 6                       | 98.60      | 0.75          | 0.04       | 0.75       | 1.20                          | Tr              | Tr             |
| <b>D. Prime Western</b> |            |               |            |            |                               |                 |                |
| 1                       | 98.00      | 0.75          | 0.08       | 1.50       | 2.00                          | Tr              | Tr             |
| 2                       | 98.00      | 0.75          | 0.08       | 1.60       | 2.00                          | Tr              | Tr             |
| 3                       | 98.00      | 0.75          | 0.08       | 1.60       | 2.00                          | Tr              | Tr             |
| 4                       | 98.00      | 0.75          | 0.08       | 1.60       | 2.00                          | Tr              | Tr             |
| 5                       | 98.00      | 0.75          | 0.08       | 1.60       | 2.00                          | Tr              | Tr             |
| 6                       | 98.00      | 0.75          | 0.08       | 1.60       | 2.00                          | Tr              | Tr             |

## Spelter Prices in New York

Following are the New York spelter prices, 1914-1918:

|       | 1914 | 1915  | 1916  | 1917  | 1918 |
|-------|------|-------|-------|-------|------|
| Jan.  | 5.33 | 6.52  | 18.18 | 9.97  | 7.88 |
| Feb.  | 5.46 | 8.86  | 20.09 | 10.49 | 7.91 |
| Mar.  | 5.35 | 10.12 | 19.10 | 10.82 | 7.60 |
| Apr.  | 5.22 | 11.51 | 18.61 | 9.73  | 7.00 |
| May   | 5.16 | 15.82 | 15.91 | 9.48  | 7.34 |
| June  | 5.12 | 22.62 | 12.80 | 9.45  | 8.04 |
| July  | 5.03 | 20.80 | 9.70  | 8.82  | 9.75 |
| Aug.  | 5.63 | 14.45 | 9.10  | 8.48  | 9.08 |
| Sept. | 5.52 | 14.40 | 9.23  | 8.26  | 9.50 |
| Oct.  | 4.99 | 14.07 | 10.01 | 8.12  |      |
| Nov.  | 5.15 | 17.04 | 11.92 | 7.00  |      |
| Dec.  | 5.67 | 16.11 | 11.28 | 7.77  |      |
| Av.   | 5.30 | 14.44 | 13.75 | 9.11  |      |

## Speeding Up Metallurgical Analysis

Pertinent Comments on the Analyst's Part in Production—Selection of Methods That are Rapid and Accurate—Arrangement of the Laboratory is Important Factor

BY HAROLD C. PARISH

IN THESE days of intensive production it becomes not only a necessity but the patriotic duty of every chemist engaged in analytical work to produce results in the shortest possible time. In order to do this he must make use of every legitimate short-cut and so plan his work that every moment is utilized to the best advantage. In laboratories where the nature and volume of work received each day is comparatively uniform and where the work can be reported in the order received, this is a comparatively simple matter. In laboratories where this is not true, the problem becomes more complicated. In many laboratories the chemists are often required to report the work received on a given day ahead of that coming in the previous day. This so-called rush work upsets the routine considerably and tends to decrease efficiency.

There are several factors which are involved in the problem of speeding up metallurgical analysis, chief among which are the following:

1. Convenient and efficient arrangement of hoods, benches, sinks, apparatus, and chemicals.
2. The proper preparation of samples.
3. Selection of such methods of analysis as will give the required degree of accuracy in the shortest space of time.
4. Planning of the work in such a way as to make every minute count.
5. Handling of the common laboratory manipulations involved in such a way as to produce maximum efficiency.

### ARRANGEMENT OF THE LABORATORY

It will be obvious that it is impossible to offer other than very general suggestions for the laboratory layout on account of variations in conditions in different laboratories as regards amount of available space and facilities. It should be the aim to have the arrangement as compact as possible and designed to save steps. Whenever possible, it will be found convenient to have the hood situated back of the worker. In any event, it is essential in a properly arranged laboratory to have hoods centrally located and of ample proportions. This is equally true of benches, sinks and balances. Obviously, the balances should be protected from laboratory fumes. The author has found it convenient to place standard solutions on a shelf above the working bench and to have the bottles or carboys containing these solutions connected with their respective burettes in such a way as to feed by gravity.

The burette stands may be set back on a bench out of the way. There should be sufficient cupboard and drawer space underneath the benches to contain apparatus in constant use. Small reagent bottles containing ammonia, the mineral acids and any other chemicals in frequent use are best located on a small shelf above

the working bench and plainly labeled. Stock reagents should also be kept near at hand. Space should be provided for as much permanent apparatus as possible. Probably as much valuable time is lost in many laboratories in setting up and dismantling apparatus every time certain determinations are made requiring special apparatus as in any other way.

### PREPARATION OF SAMPLES

It is obvious that the condition of samples has considerable influence upon the speed of weighing and the solution of these samples in acids. It is a very difficult matter to weigh or dissolve coarse samples rapidly. Furthermore, the accuracy of many methods depends upon the comparatively fine division of the samples. For sampling soft white metal alloys a coarse rasp or a hack saw gives a very satisfactory sample. A hack saw may also be used for sampling copper, brass or bronze. These latter alloys, as well as iron and steel, may also be sampled to good advantage with a flat or a twist drill which has the sharp edge of the lip slightly dulled by grinding. This treatment of a twist drill eliminates coarse curly drillings. Obviously, care should always be taken to obtain representative samples. In determining carbon in steel or iron the author uses only those drillings which pass a 20- and remain on a 60-mesh sieve. In this way very excellent results may be obtained.

### SELECTION OF METHODS OF ANALYSIS

It is a deplorable fact that a large number of chemists are using the longer methods of analysis when results of equal and sometimes greater accuracy could be obtained by the use of shorter ones. Every chemist should be alive to this vitally important phase of the problem and always be on the lookout for shorter methods of analysis or means of eliminating unnecessary steps in procedures already in use. If he is not certain of the accuracy of a method new to him, he should check it thoroughly against one known to be reliable. Published methods of procedure are too often followed mechanically without a thought as to whether or not they can safely be shortened. A little experimental work would often point out modifications which would not interfere with the accuracy of the analysis. Maximum accuracy required plus maximum speed should be the aim of every analyst.

It may be of interest to mention methods used in iron and steel analysis which seem to give this desirable combination. No attempt will be made to go into detail except in one or two instances, as most of the procedures are so well known by name that no description is necessary. Shorter methods have been tried in many instances, but have not been adopted because they did

not prove reliable. Some readers may be using procedures which are still shorter and give equally accurate results. If so, they should certainly publish them in the interests of efficiency if they have not already appeared in the literature. The following is a list of methods used in this laboratory in steel analysis.

*Silicon.* Drown's method.

*Manganese.* Bismuthate-arsenite.

*Phosphorus.* Alkalimetric titration of the ammonium phosphomolybdate.

*Carbon.* Direct combustion at 1000 deg. C. and absorption of  $\text{CO}_2$  in 12-mesh soda-lime containing 15 per cent water.

*Sulphur.* Evolution method. Precipitation of  $\text{H}_2\text{S}$  as cadmium sulphide and titration with standard iodine solution.

*Chromium.* A further modification of "Barba's Modifications" described in Blair's "Analysis of Iron."

*Nickel.* A modified cyanide method.

*Vanadium.* Johnson's method, titrating with ferrous ammonium sulphate, using potassium ferricyanide as an indicator.

*Tungsten.* Rapid method described in Blair's seventh edition, page 204.

A description will be given of the methods mentioned above for chromium and nickel. A few suggestions for saving time in operating some of the other methods may be helpful to someone.

*Carbon.* The only point that suggests itself regarding the determination of carbon is that time can be saved by weighing all of the determinations to be made for the day in one sitting. In this way there will always be a sample ready to put into the furnace as soon as another one is taken out and there will be less interference with other work.

*Silicon.* The method of Drown calls for the solution of the sample in a mixture of nitric and sulphuric acids, evaporation to the evolution of  $\text{SO}_2$  fumes, solution of residue in water or dilute HCl, filtration of  $\text{SiO}_2$ , ignition and weighing. In this determination the  $\text{SiO}_2$  can be filtered much more rapidly if the residue is dissolved as soon as possible after evaporating to fumes and filtered immediately while still hot. If the washing of  $\text{SiO}_2$  with dilute HCl and hot water is sufficiently thorough, it should not be necessary to make an evaporation with HF after ignition and weighing. If the  $\text{SiO}_2$  is not pure white, however, after ignition, this evaporation must be resorted to. One weight can be avoided by carefully brushing the  $\text{SiO}_2$  into balanced watch-glasses instead of weighing the crucible.

*Manganese.* The determination of manganese is carried out just as described in Blair's seventh edition, page 122, up to the point of titration, when standard sodium arsenite is used as described in Lord & Demorest's "Metallurgical Analysis" under the "Bismuthate-Arsenite" method. A porous alundum thimble is used for filtering the solution by suction previous to titration.

*Phosphorus.* The alkalimetric determination of phosphorus in iron and steel is equally as accurate as the Emmerton process of reducing a solution of the ammonium phosphomolybdate with zinc and titrating with  $\text{KMnO}_4$ , and everyone who has used both methods will agree that much time can be saved by using the former.

*Sulphur.* Where many sulphur determinations are made it is best to have a sulphur rack built and connected with the gas supply as a permanent laboratory fixture. The number of determinations which it should accommodate at one time depends, of course, upon the volume of work handled each day. The one the author uses carries ten.

*Chromium.* Barba's modification, referred to above and described on page 197, Blair's seventh edition, calls for the addition of a comparatively large excess of  $\text{KMnO}_4$  to oxidize chromium after the solution and oxidation of a 1½-gram sample with  $\text{HNO}_3$ . This excess is destroyed with ammonia, the solution again acidified with  $\text{H}_2\text{SO}_4$ , boiled,  $\text{MnO}_2$  filtered off, aliquot taken representing 1 gram and the solution titrated with standard ferrous ammonium sulphate and potassium permanganate.

The author has for some time used a modification of this method which has served for several hundred determinations and been found to give results equally accurate and to be more rapid. A 1-gram sample is dissolved and oxidized with nitric acid, exactly the same as described by Blair. After the oxidation the solution is then diluted to approximately 100 cc., brought to a boil, and while boiling, a saturated  $\text{KMnO}_4$  solution is added a few drops at a time from a pipette, the solution being warmed between each addition, until a permanent precipitate of  $\text{MnO}_2$  is obtained. The solution is then boiled for 15 or 20 minutes, or until upon removal from the application of heat the precipitate settles rapidly leaving a clear yellow supernatant liquid free from pink tints. The solution is cooled, filtered and titrated as usual with ferrous ammonium sulphate and potassium permanganate.

If vanadium is desired, the pink produced by the  $\text{KMnO}_4$  should be just destroyed with the ferrous ammonium sulphate solution, exactly 2 cc. of a 2 per cent potassium ferricyanide indicator added and the vanadium titrated with ferrous ammonium sulphate to the destruction of yellow tints, according to Johnson.

*Nickel.* Several years ago Mr. Arthur G. Carman, formerly connected with this laboratory, worked out a modification of the cyanide method which the author believes to be the most rapid method in use for this determination. The method is carried out as follows:

Dissolve 1 gram of steel drillings in a 400-cc. beaker with 20 cc. 1:1 HCl. When action ceases, add 10 cc. of 1:1  $\text{HNO}_3$ . Boil until the red fumes have been driven off and the carbon is completely destroyed. Add 100 cc. of citric acid solution, dilute to 300 cc., and add with a pipette exactly 5 cc. of standard  $\text{AgNO}_3$  solution. Now add just sufficient ammonia to destroy cloudiness, then 2 cc. of KI solution and titrate with standard KCN solution to the disappearance of turbidity. This titration is best done by transmitted artificial light, placing the beaker on a piece of black glazed paper. The end point is easy for an experienced operator to detect and is not reached as long as a drop when striking the solution produces a spot clearer than the solution around it. As soon as the end point is reached all turbidity will have disappeared. If it is thought that the end point is passed, add a measured amount of  $\text{AgNO}_3$  solution until turbidity just appears. It is best to have another beaker containing a solution



to be titrated, to which no  $\text{AgNO}_3$  has been added, placed beside the one being titrated so as to have a clear solution for comparison. If the citric acid was dirty, the solution will be cloudy and should be filtered before the  $\text{AgNO}_3$  is added.

#### *Solutions:*

*AgNO<sub>3</sub>.* Dissolve 2.885 grams of C.P.  $\text{AgNO}_3$  in water and dilute to 1000 cc.

*KI.* Dissolve 50 grams of C.P. KI in 250 cc. of water.

*Citric Acid.* Mix 380 grams of C.P. ammonium sulphate, 270 cc. of concentrated ammonia, 1430 cc. of water, and 240 grams of citric acid.

*KCN.* Dissolve 8.85 grams of pure, or 9.03 grams of 98 per cent KCN and 10 grams of KOH in water and dilute to 2000 cc.

*Standardization.* The KCN solution is most conveniently standardized against a U. S. Bureau of Standards 3.50 per cent nickel steel, the same procedure being followed as above. An additional titration must be made in order to obtain the relation between  $\text{AgNO}_3$  and KCN. This is accomplished in the solution after titration for standardization by adding exactly 10 cc. standard  $\text{AgNO}_3$  to solution and running in standard KCN to disappearance of turbidity. One-half of the amount of KCN required is to be subtracted from the amount used in each determination.

#### *Notes:*

1. The presence of sulphates is necessary to obtain a sharp end reaction.  $\text{AgI}$  is soluble in a large excess of  $\text{NH}_4\text{OH}$ , so care should be taken to have the solution only slightly alkaline with  $\text{NH}_4\text{OH}$ .
2. If the titrated solutions are allowed to remain in open beakers for some time, a white film forms on the surface but no account is to be taken of it.
3. When chromium is present in appreciable amounts the same procedure is followed, except that it may be necessary to add a little more citric acid solution in order to hold the chromium in solution when ammonia is added.
4. The  $\text{AgNO}_3$  solution used should not be stronger than that indicated above, for when a stronger silver solution is used, the  $\text{AgI}$  instead of forming a turbid solution settles out as a curdy precipitate which does not readily react with the cyanide. If a ferro-nickel is being analyzed a stronger solution of KCN should be used.
5. Such elements as V, Cr, W, Mo or Mn do not interfere even when present in large amounts in the sample. Copper, however, is titrated with KCN but is usually present in negligible quantities. If its presence is suspected, nickel should be determined by the dimethylglyoxime method.

*Vanadium.* This method will be found described in Johnson's "Chemical Analysis of Special Steels," also Lord & Demore's "Metallurgical Analysis."

#### NON-FERROUS ALLOYS

The number of different methods of analysis used in non-ferrous alloy work is so great that it would be practically impossible to deal with them comprehensively in this paper. The author uses electrolytic methods for determining copper, lead and zinc in brass and bronze where the lead does not exceed 10 per cent. If the alloy contains more than 10 per cent, the lead

is determined as  $\text{PbSO}_4$ . Some means of agitating the solutions when electrolysis is in progress will aid in obtaining quick results. Rotating anodes or cathodes may be used for this purpose, also solenoids, or even compressed air. Where allowable, much time can often be saved by taking some element by difference after all other elements present have been carefully determined. It is perfectly legitimate and accurate, providing the other figures are correct. Whenever determined in this way the fact should be noted in reporting. For instance, in the analysis of Muntz metal, copper, lead and iron may be determined accurately in a very short time. Tin or any other impurities may also be tested for or actually determined quickly. After this is done there is no reason whatever why zinc should not be reported as the remainder, unless for some reason the practice is not allowed. The practice is a dangerous one if not carried out in a conscientious manner. It is never done in this laboratory except with the full knowledge and consent of the client, as some object for reasons best known to themselves. The majority, however, prefer to have it done this way where speed is a factor.

The white metal alloys cover a very large field and include babbitt metals, solders and aluminum alloys. Various types of babbitt metals require different procedures. For instance, tin-base babbitts must be handled in a different way than lead-base babbitts, while those alloys containing more antimony than tin act differently than those in which tin predominates. In fact, the subject is such a broad one that it would be impossible to do it justice in this article. Chemists who are doing this sort of work should always bear in mind the point made above regarding the possibility of using shorter methods of procedure. Get in touch with your fellow chemists and find out what methods they are using. Search the literature also, keeping in touch with the current information. If someone publishes a method which looks reasonable and seems shorter, do not be afraid to try it. If it gives satisfactory results after a thorough trial, adopt it. Many methods with excellent possibilities are condemned after one trial, often when it is not the fault of the method itself, but because the operator had not learned how to handle it properly. Many chemists are using long procedures which have been handed down to them simply because they give accurate results and because they have not the necessary nerve to find out for themselves if a shorter one will prove to be as accurate. If everyone assumed this attitude there would be no progress.

#### PLANNING THE WORK

Here, too, it is difficult to offer any very specific suggestions on account of differences in conditions such as nature and volume of work, whether or not it can be handled in the routine manner, facilities, etc. The first thing to bear in mind in planning the work in a busy laboratory is that every minute must be utilized to the best advantage. It is customary in many laboratories to divide the analyses between several men who always make the same determinations. This seems to be the most efficient way of handling it, and wherever possible it is preferable.

The author has found that it works well to weigh all samples for the day's work at one sitting and to start

them all off as quickly as possible. Those determinations which will need no attention for some time should be started first and others which require considerable attention can be worked in. Moreover, if there are several miscellaneous samples upon which similar determinations are required, these should all be run along together, or at least as many as facilities will allow. It will often prove to be a saving of time to sit down at the beginning of the day and to spend a few minutes merely making plans for the day's work. It will not always be possible to adhere strictly to these plans, but it will help considerably.

There are many ways of saving time in the common manipulations which it may seem superfluous to mention. Still, they are important from the standpoint of speed, and not all chemists make use of them. It is only for such analysts that the suggestions are intended.

There is the question of filtering. One of the first things a chemist usually learns in a laboratory or in college is how to choose a good funnel and how to fit a filter paper into this funnel properly. In spite of this it is surprising how many are careless in this respect and do not seem to realize how much unnecessary time may be lost by slow filtrations. It is not the intention to describe how this should be done, as it is too well known, but merely to call attention to the importance of painstaking in this direction. It is sufficient to say that the filter paper should fit perfectly. Long straight-stemmed 60 deg. funnels work best. They will be found to filter faster if the angle formed by the stem and funnel proper is abrupt, rather than flaring.

The grade of filter paper is also important. A paper of no closer texture should be used than is necessary to hold the precipitate which is being filtered. If possible, a column of liquid should be maintained in the stem of the funnel. This may be done either by gentle pressure on the mouth of the funnel with the palm of the hand or by playing a strong stream from the wash bottle around the upper edge of the filter paper. Many slow-filtering precipitates, such as aluminium hydrate, may be filtered and completely washed in two to three minutes by using suction and a Buchner funnel. It will be found a great time saver in weighing, instead of having the balance adjusted to zero to have it so adjusted that the pointer will swing three divisions to the right. This saves waiting for a swing in both directions. It is obviously necessary to have it swing the same distance before and after the weight.

The use of factor weights in gravimetric work saves considerable time in calculations. In weighing steel samples a magnetized spatula may be used to good advantage in the final adjustment. It will also be of value in steel work to bear in mind the fact that it is a waste of time to attempt to weigh samples for those elements such as sulphur, phosphorus, silicon etc. which are present in small quantities with the degree of accuracy necessary with higher percentages. Much time, also confusion, may be saved by always forming the habit of arranging numbers in order when filtering etc., the lowest number always at the left, or right, as the operator prefers.

#### CONCLUSIONS

It is realized that many of the suggestions which have been offered will seem too obvious to many to war-

rant publication. On the other hand, if a solitary chemist is assisted by anything which has been offered, the paper will be justified. The valuable assistance that can be obtained by keeping constantly in touch with one's fellow workers and by making occasional visits to other laboratories cannot be overestimated. Do not be afraid to admit that someone is doing something in a way of which you have never heard. By doing so you may create a barrier between yourself and valuable information. Do not lose sight of the fact that your knowledge, as well as that of everyone else, is limited; admit it by asking questions. The other fellow will think more of you and tell you more.

Arthur D. Little, Inc.,  
Cambridge, Mass.

## A New Method of Microscope Illumination

(Second Paper)

BY ALEXANDER SILVERMAN

IN A NUMBER of papers<sup>1</sup> which have appeared during the past year the writer described a new illuminator for microscopes.<sup>2</sup> The supplementary material here given is presented for the benefit of those already using the device and for others who may be interested.

**The Lamp.**—A new 9-volt, 0.7-ampere daylight (blue glass) lamp has been devised, which will yield 50 per cent more light than the old 6-volt, 0.7-ampere lamp. The illumination is not only better but the terminals of the lamp are closer together so that the filament more nearly approaches a complete circle. Researches which are under way may provide a lamp of still greater light intensity. A new enamel is employed for the reflector to prevent the scaling experienced with the old type.

**The Rheostat.**—A tube resistance with three connecting-posts for 107 v., 112 v., and 118 v. permits of the use of the lamp with the ordinary A.C. or D.C. lighting circuit. A similar device for 220-v. circuits is in preparation. By connecting on a lower voltage tap the light may be increased for photographic purposes.

**Heat Insulation.**—Although the writer has had the illuminator attached to objectives and going constantly for a half hour at a time, no injury was suffered by the objectives. The circular space of about one-quarter of an inch between the holder and the objective permits cold air to circulate between the two. Although the heat radiated and conducted should not prove serious, an effort is being made to lower the temperature of the lamp by reducing the size of the anchor wires. Radiated heat may be cut down by giving the lamp a black coat over the white enamel reflector.

**The Shutter.**—A shutter has been devised which may be slipped into the holder for cutting off the light from one-half of the field. The shutter may be revolved so as to send oblique light from any side to the specimen under examination. This is of value in detecting pearly structure in iron, etc.

**Vertical and Oblique Light.**—The new illuminator may be attached to the microscope without removing the

<sup>1</sup>J. Ind. Eng. Chem., 9:971 (1917). Met. & Chem. Eng., 15:318 (1918).

<sup>2</sup>U. S. Pat. 1,267,287. Can. Pat. 185,233. Other U. S. and foreign patents pending.

vertical illuminator, thus affording a rapid comparison of the effect of vertical and oblique light. Details may be visible under one illuminator which would not appear with the other. For example the interior of small pores and slag pits is usually black under vertical light, while the new illuminator shows depth and the nature of the content if slag or other substances are present.

**Photomicrography.**—Some metallographers are still skeptical because of the low power of the lamp, as they have been accustomed to using arc lamps or powerful nitrogen-filled tungsten lamps.

As has been intimated in earlier papers, definition in ordinary photography is obtained by using a very small aperture and giving a long exposure. The writer's experience has been that excellent photomicrographs are obtainable with the new lamp in a few minutes by removing the eye-piece and that with 8-mm., 16-mm., and objectives of lower power, even 60-mm., clear images are obtained on the ground glass. Even better results may be obtained using a very fine etched ground glass and rubbing the dull surface with a little vaseline, afterwards removing as much of it as possible with a dry cloth. Fine definition is possible with highly polished steels, brasses, bronzes, etc. Even ball bearings give a clear image on the treated ground glass.

The writer desires to express his appreciation of the valuable suggestions made by numerous scientists who are doing pioneer work in this new field of micro-illumination.

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## Electrolytic Refining of Antimony

BY Y. C. WONG

LOW grade antimony ores are not a commercial source of antimony at the present time, although for over thirty years many chemists have from time to time, chiefly under the stimulus of war-time metal prices, patented processes for extracting antimony by means of a cheap solvent and depositing the pure metal electrolytically. That antimony could be electrolysed from alkali antimony polysulphides was reported by Lukon<sup>1</sup> in 1880, Classen<sup>2</sup>, and Ludwig<sup>3</sup>. Dr. W. Borchers<sup>4</sup> developed a commercial process at one time used in Germany for extracting with boiling sodium sulphide, which solution was conducted through a series of ten cells, wherein the antimony was all deposited. It was found that the metal was deposited in equal quantity, both from thio-antimonates and thio-antimonites; an excess of sodium sulphide, as was proposed by Classen and Ludwig, or sodium hydroxide was found essential in order to prevent separation of sulphur at the anode, the amount of this addition being such that after the removal of the antimony there is at least one atom of sodium to every atom of sulphur—in other words, the reaction takes place best when three molecules of sodium sulphide (Na<sub>2</sub>S) are present for each molecule of antimony sulphide (Sb<sub>2</sub>S<sub>3</sub>). Solution such as sodium hydroxide, potassium hydroxide, ammonium sulphide etc. are very satisfactory for laboratory work but not the most

economical for commercial purposes. Siemens & Halske (D. R. Pat. 67,973, 1892) and von Engelhardt and Nettel (U. S. Pat. 568,843, 1896) used the alkali earth sulphides and regenerated the solution, thus obtaining a cycle with but small losses. A current density of 0.8 amperes per sq. cm. with a voltage of 0.8 gave 76 per cent efficiency, 0.621 kilograms of antimony being refined per kw.-hr.

### LABORATORY WORK

In preparing extraction solutions for test purposes in the laboratory, 27.8 grams of quick-lime and 22.2 grams of flowers of sulphur are mixed in a liter beaker, then covered with 750 cc. of water and the mixture heated on a hot-plate for 45 minutes, stirring continuously to prevent the beaker from cracking. After the cherry-red color has appeared and no more sulphur flowers gather on the surface of the solution it is filtered, cooled, and the filtrate transferred into a bottle and diluted with water to 2 liters. The reaction is as follows:



In testing some antimonial extracts, several 40 cc. portions were taken, giving on analysis 0.962 grams of antimony, to which were added 15 cc. of calcium sulphide solution (sp. gr. 1.18), gram of sodium chloride, 4 cc. of sodium hydroxide solution (10 per cent) and diluted to 400 cc. with hot water. In commercial work, the diluting liquor would be the wash water used in removing the calcium thio-antimony salts from the extraction tanks. In electrolysis, the cathode used was a plane cylinder of platinum foil, 3 by 8 cm., having an exposed surface of 39.3 sq. cm. and weighing 10.71 grams. A heavy platinum wire about 3½ cm. long was attached to the external circuit. A helix of platinum wire ½ cm. in diameter served as the anode, which was placed within the cathode. With a voltage of 1 to 1.2, and a current of 0.4 amperes, 90 per cent of the antimony was deposited in one hour. As the form of the deposit is not a criterion, greater current density could be used to speed up the process. If too large an excess of sodium hydroxide be present, the antimony will form a black, powdery, non-coherent deposit.

A fair estimate of the cost of refining by this process on an industrial scale based on comparative data from general electro-metallurgical costs would be five cents per pound. As a 36 per cent ore sells at about 88 cents per unit, the antimony would cost 4.4 cents per pound in the ore state. After transportation, brokerage and incidental charges are paid, a profit of 2½ to 3½ cents per pound of refined metal would remain at the present price of 13 cents.

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### Lead Prices in New York

Prices for lead at New York from 1914 to 1918 were quoted as follows:

|       | 1914 | 1915  | 1916 | 1917   | 1918  |
|-------|------|-------|------|--------|-------|
| Jan.  | 4 11 | 3 74  | 5 94 | 7 56   | 6 62½ |
| Feb.  | 4 06 | 3 22  | 6 23 | 8 34   | 7 14  |
| Mar.  | 3 97 | 4 03  | 6 83 | 8 98   | 7 25  |
| April | 3 82 | 4 20  | 7 50 | 9 00   | 7 08½ |
| May   | 3 90 | 4 23½ | 7 50 | 9 71   | 7 00  |
| June  | 3 90 | 5 87½ | 7 02 | 10 81  | 7 51  |
| July  | 3 90 | 5 74  | 6 54 | 11 00  | 8 04  |
| Aug.  | 3 80 | 4 75  | 6 25 | 10 94½ | 7 75  |
| Sept. | 3 86 | 4 62  | 6 75 | 8 91   | 8 05  |
| Oct.  | 3 54 | 4 59½ | 7 00 | 6 84½  |       |
| Nov.  | 3 68 | 5 15  | 7 00 | 6 14½  |       |
| Dec.  | 3 80 | 5 34½ | 7 44 | 6 25   |       |

<sup>1</sup>*Zeitschrift für Analytische Chemie*, P. 14, Vol. xix, 1880.

<sup>2</sup>Classen, "Quantitative Analysis Durch Electrolyse."

<sup>3</sup>*Berichte der Deutschen Chemischen Gesellschaft*, P. 1104, Vol. xviii, 1885.

<sup>4</sup>Borchers, "Electrometallurgie."



## The American Pyrophoric-Alloy Industry\*

### Development of the Rare-Earth Industry in Connection with Welsbach Gas Mantles—the Cerium Group By-Products and Their Domestic Production

By ALCAN HIRSCH

THE pyrophoric-alloy industry is very young, and intimately associated with the rare-earth industry which is also of comparatively recent origin. In order to make the situation clear, it will be necessary briefly to outline the meaning, foundation and history of the rare-earth industry. The term refers to those industries which mine, separate, purify and use the earthy metals or salts of metals formerly considered rare; i.e., gerium, lanthanum, didymium, yttrium, zirconium and thorium. The rare-earth industry was founded in 1885 by an Austrian, Baron Auer von Welsbach, who while investigating certain ores discovered the brilliant light-emitting qualities of their oxides, and invented the incandescent gas mantle. This mantle was made of oxides of lanthanum and zirconium to which a little cerium oxide was added. Welsbach secured patents in various countries, and sold them to investors. About 1887 the industry took root in the United States with the formation of the Welsbach Light Company.

The early gas mantles proved somewhat of a disappointment. Welsbach was in danger of being discredited and pushed his research further, particularly investigating ores of thorium. The early mantles only gave about ten candlepower with a combustion rate per hour of one cubic foot of gas, but the use of thorium salts considerably improved this, and purer and still purer thorium salts were tried until finally they were refined to the extent that they emitted no light at all. To make a long story short, it was found that while thoria should be almost the entire constituent of a mantle, the presence of one or two per cent of other oxides, chiefly that of cerium, was essential to high light-emissive value. This leads us to the present incandescent gas mantle, with which we are indirectly concerned in so far as its production leads to by-products from which pyrophoric alloy is produced.

#### CERIUM RECOVERED FROM GAS-MANTLE WASTES

The original sources of thoria (thorite) in Norway proved totally insufficient in quantity to supply the demand for gas mantles. The manufacturers, therefore, turned to monazite sand, found rather plentifully in Brazil and India and to some extent in North Carolina, as a source of thoria. About 15 to 30 per cent of monazite sand is phosphoric acid, the bases of which mainly consist of various oxides of the rare earths, 20 to 30 per cent oxide, 20 to 30 per cent oxides of lanthanum and didymium in varying proportions, and small percentages of the yttrium and zirconium oxides. All of these are practically useless in any quantity in the gas-mantle business. It is the 2 to 10 per cent of thorium oxide, averaging about 6 per cent, for which

the monazite sand is refined. More than a quarter of a million pounds a year of thorium oxide is produced in the United States from about five million pounds of monazite sand, of which the by-product is mostly wasted. This by-product of so-called "cerium oxides" or "mixed rare-earth metal oxides" amounts to considerably more than a million pounds per annum, and constitutes the raw material for making pyrophoric alloy.

It should here be made clear that what is called "metallic cerium" and used as such, is really a mixture of cerium, lanthanum, didymium, samarium, etc., all very closely allied and very similar metals. It is not necessary to separate them, but the salts for making the metal must be purified. The process for making metallic cerium and the like is described in U. S. Patent 1,273,223, July 23, 1918, to Messrs. Alcan and Marx Hirsch.

The cerium metals are reduced in an electric furnace by electrolyzing their molten salts. The first step is to obtain the electrolyte. We have found that to secure an electrolyte suitable for the continuous commercial production of metallic cerium, certain special precautions are necessary. Certain rather limited ranges of temperature are required for efficiently performing the two processes carried out in the electrolytic cell, and these are called respectively "separating temperature" and "agglomerating temperature." The electrolyte is prepared preferably by using the oxides described above which are the by-product from the incandescent gas-mantle industry. The cerium group oxides are dissolved in commercial hydrochloric acid, reasonably free from sulphuric acid and sulphates, using as little heat as possible, and preferably maintaining an excess of the oxides. The solution consists of a mixture of the chlorides of cerium, lanthanum, didymium, samarium, yttrium, thorium and other rare-earth metals, of which cerium is the chief constituent.

Contrary to common belief, the purity of this solution is not important except for the percentages of sulphur and phosphorus compounds on the one hand, and for the bivalent bases such as iron and aluminium compounds on the other, which should each be reduced below 3 per cent. An excess of cerium oxide will precipitate the iron and aluminium, and calcium chloride (or better barium chloride) will throw down the sulphates and phosphates.

#### PREPARATION OF THE CERIUM SALTS FOR ELECTROLYSIS

The solution is then clarified by filtering hot or settling, and evaporated to dryness. The preparation of electrolyte should be so carried out as to secure the proper surface tension conditions between the fused electrolyte and the fused metal when produced in the electrolytic bath. An excess of certain impurities, in-

\*A paper read at the Fourth National Exposition of Chemical Industries, New York, Sept. 27, 1918.

cluding oxychlorides, such as cerium oxychloride, I believe, tends to reduce the surface tension between the metal and electrolyte in the bath and to alter the viscosity, producing an emulsion of colloidal solution of metal in the electrolyte and preventing the separation of the metal from the bath. The oxychlorides may be removed in either of two ways. The chloride solution obtained as above may be evaporated to dryness and then fused in an atmosphere of hydrochloric acid gas to produce complete reduction as well as to prevent oxidation of the electrolyte by the air or dissociated steam. The wet acid gases are condensed hot and dried, and the concentrated hydrochloric acid gas may be used over again. The second and usual method of making the double chloride of sodium and cerium does not yield a desirable bath for electrolysis. If, however, about 15 per cent sodium or potassium chloride (insufficient to make the double salt), and 15 per cent of ammonium chloride by weight, based on the dry weight of the dissolved rare-earth chlorides, are both added before the evaporation to the chlorides after the excess of iron, aluminium, sulphur and phosphorus impurities are removed; the solution may then be evaporated to dryness and dehydration carried through to fusion of the chloride without the production of characteristics resulting in objectionable tension phenomena in the electrolytic bath. The ammonium chloride is dissociated upon fusion and forms a chlorinating agent as does the hydrochloric acid gas in the first method, and may be similarly recovered and used continuously in the process. When the electrolyte formed in this way is subjected to electrolysis, the alkali chloride accumulates in the cell. After the removal of the metallic cerium or "mischmetall," it may be thrown away or dissolved in hydrochloric acid, purified as above explained, and added to the fresh electrolyte.

#### THE ELECTROLYSIS OF THE CERIUM METALS

The electrolysis is preferably carried out in pots of cast iron high in carbon and silicon, about 8 in. in diameter and 12 in. to 18 in. in depth, usually set in brick work and externally heated. Heat should be applied almost wholly at the bottom of the pot. It is undesirable to fill the cell as described in the literature. We begin the electrolysis with almost an empty cell, heating a small amount of electrolyte with gas nearly to fusion when the electric current completes the fusion. Thereafter continuing the electrolysis, we gradually add electrolyte, building up the charge in the pot continuously until it is practically full, and a termination of the run is brought about. Either carbon or graphite anodes may be used. But they each have a critical density; that is, one above which current may pass without deposition of metal. For graphite this is about six to seven amperes per square inch of anode surface, and for carbon about five and one-half amperes. Furthermore, we find it desirable to maintain a relation between current density at the anode and cathode, the latter being about one-quarter to one-third of the former, in order to secure a desirable electrical circulating heating effect. By adding solid lumps of electrolyte to the bath, the temperature of the cell is lowered when it becomes too hot. It also contributes a portion at least of the charge required for building up the bath.

As the run approaches 24 to 26 hours in duration, when electrolyte made with the alkali salts is used, the sodium salt accumulates in the charge to such an extent that it becomes advisable to terminate the run. We have found that certain precautions for this termination are necessary in order to secure good yields of cerium. Therefore, preparatory to shutting down the run, we turn on the heating torch full blast, and also increase the current, stirring up the charge in the cell thoroughly about every half hour, for two or three hours. The contents of the cell will be in a very fluid condition if the electrolysis has been properly carried out. The current is shut off, the anode taken out, and the bath moderately and thoroughly stirred for about five minutes, care being taken to cease stirring well before the bath begins to thicken. If iron pots are used, it is most practical to break the pot after cooling to separate the button of metal from the electrolyte.

#### PREPARATION OF PYROPHORIC ALLOYS

This relatively pure mixed cerium metal or "mischmetall" is soft and does not spark easily on scratching. Consequently, to make pyrophoric alloy it must be made harder, and is alloyed with about 30 per cent of other metals, chiefly iron, to make the commercial sparking metal or pyrophoric alloy which is formed into small pieces to make the "flints" used in lighters, igniters mechanical fuses, etc. The alloy enters into commerce in the form of small strips, rectangular or round, of varying lengths varying from 200 to 2000 pieces per pound. The most general form is a round piece approximately about  $\frac{1}{8}$  in. in diameter and  $\frac{1}{2}$  in. long, of which there are from 1500 to 2000 pieces to the pound.

The manufacture of these small pieces—the only form in which "mischmetall" is salable—is a most difficult operation requiring what is comparable to equipment for the manufacture of fine jewelry.

#### THE AUSTRIAN PYROPHORIC ALLOY INDUSTRY . .

Baron Auer von Welsbach developed the improvement of hardening the relatively soft cerium with iron to make a hard metal which would emit sparks when scratched. He took out patents on this invention the world over. The German and English patents were litigated and held restricted to the use of iron and its equivalent in substantially the 30 per cent named. This is to say, in England the courts held that Welsbach was entitled to protection only on the iron alloys. The United States courts have sustained the patent much more broadly to include and cerium-containing material hardened with any alloy metal to make the pyrophoric alloy. When Welsbach and his associates developed the pyrophoric-alloy business, they did not form separate companies in each country, but centralized the manufacture of cerium and pyrophoric alloy in the Treibacher Chemische Gesellschaft of Treibach, Austria (a part of the rare-earth cartel or trust). As stated above, they established branches of this Austrian company in England, France, Russia, United States, etc. It was not until some time after the first attack on France by Germany that a pound of cerium was made anywhere in the world outside of the Central Powers so far as I can learn, and then it was made by the New Process Metals Co., which operates under our basic patent on metallic cerium.

Therefore, to reiterate somewhat for the sake of clearness, until the start of the European war the pyrophoric-alloy business of the world was operated as follows: The German and Austrian rare-earth gas-mantle cartel or trust turned over to the Treibacher Chemische Gesellschaft a large part of their cerium residues, which the Treibacher company made into metallic cerium. The Treibacher company exported this metallic cerium to its branches in France, England, United States etc. which branches alloyed the metallic cerium with about 30 per cent of iron and other metals, and cast the alloy into small pieces, selling these pieces to the manufacturers of pocket lighters, miners' lamps, gas lighters, etc. The business of marketing the small pieces of pyrophoric alloy was protected by the patent mentioned which has been contested, and as stated, very broadly sustained in this country.

The American branch of the Treibacher Chemische Gesellschaft was established about 1907, and handled all the pyrophoric-alloy business in this country. After August, 1914, the efficiency of the British Navy made it impossible for the Treibacher company to deliver cerium metal to its agency in the United States. They tried by every means to secure cerium metal from Austria, even trying to import it by the submarine *Deutschland*, but were unsuccessful.

In 1915 the American agency of the Treibacher company got in touch with a chemical company in this country and tried to have this company produce metallic cerium for them. After working several months this company was unable to do so. The president of this company then learned that I had secured my degree from the University of Wisconsin as the result of research on the electrolytic preparation of metallic cerium, and engaged my firm to work out a process for the commercial manufacture of this metal. My brother and other assistants were associated with me in our joint laboratories. After several months of intensive work in the laboratory, metallic cerium was commercially produced of satisfactory quality and in regular quantity. Thereupon the New Process Metals Company was formed which manufactures and sells this material. From that time until April, 1917, the New Process Metals Company furnished metallic cerium to the American branch of the Treibacher Chemische Gesellschaft located in New York City.

#### THE FORMATION OF AN AMERICAN COMPANY

In April, 1917, the manager of the American branch of the Treibacher concern formally notified the New Process Metals Company that he personally, doing business under the name of the American Pyrophor Company, had purchased the business of the Treibacher Chemische Gesellschaft. From April until December, 1917, the New Process Metals Company continued to furnish metallic cerium to the American Pyrophor Company. After war against Austria was declared, the property of the American Pyrophor Company, or the Treibacher Chemische Gesellschaft, whichever you choose to call it, was taken over by the Alien Property Custodian of the United States.

From the foregoing it is seen that the New Process Metals Company developed the cerium business in America. From shortly after the start of the war until the autumn of 1917, it was the only company in the

world outside of the Central Powers making metallic cerium, and the pyrophoric alloy made from this product supplied the needs of the armies and civil populations of Russia, France, England, South America, United States, etc. In this connection, it is interesting to note that the cerium lighters have been extensively used in the trenches, first because of the great scarcity of matches in Europe, and second because of the effect of dampness on matches. We are glad to be able to say that for several years prior to 1918 we supplied the British and French Armies with their requirements of pyrophoric alloy. Now this metal, we understand, is being made in France.

The future of the pyrophoric-metal business in this country is an interesting field for speculation. We hope to be able to maintain it to some degree at least. Frankly, it is our potential ability to market our alloy in the form of lighters upon which we rely for the continuance of our company, and we anticipate that our lighter manufacturing facilities will become so developed and economical as to enable us to meet Austrian competition successfully after the war.

## Speeding Up the Steel Works Laboratory

BY H. C. KIMBER

IN THESE strenuous times it falls to the lot of many to remain at home to produce the materials necessary to the continuance of warfare. It is imperative that every bit of energy and every minute be conserved in order that the army and navy may receive the best material that it is possible to make in minimum time.

The following suggestions and methods of analysis have proved of great value in the production of electric steel. A  $\frac{3}{8}$ -inch flat high-speed drill produces excellent drillings for weighing, as they are practically free from the curls produced by the twist drill. There is a natural tendency for the chemist to spend too much time weighing out the samples. The degree of accuracy necessary may easily be calculated.

For example, it is not necessary to weigh a five-gram sample for sulphur as accurately as a two-tenths gram sample for manganese.

Automatic overflow burettes and pipettes are convenient and almost indispensable in small laboratories having a large amount of work to be done each day. With these burettes and pipettes large quantities of standard solutions may be made up at one time and economically used. A suggestion for the titration bench is shown in Fig. 1. The clips which hold the burette in place are fuse clips used to hold 220-volt fuses. The burette is rigid and every graduation is visible.

An excellent routine method for the determination of carbon in steel is outlined below.

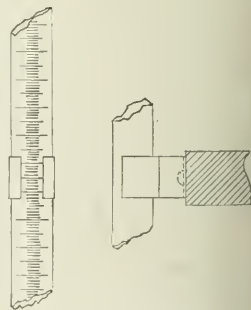


FIG. 1.—BURETTE CLIPS



## THE TRAIN BEFORE THE COMBUSTION

The apparatus, shown in Fig. 2, consists of a calcium chloride tower *B* filled with sticks of sodium hydroxide, or half filled with calcium chloride, and half with soda lime, the former on top; a twelve-inch tube *E* made of  $\frac{3}{8}$ -inch glass tubing, a Y-tube *D*, an equalizer *C*, and a stop-cock *F*. Immediately after the combustion apparatus *G* there is connected to the combination tube an orifice *H* which regulates the flow of oxygen through the train.

The tower *B* containing the sodium hydroxide or soda-lime is connected directly to the oxygen gage *A* and

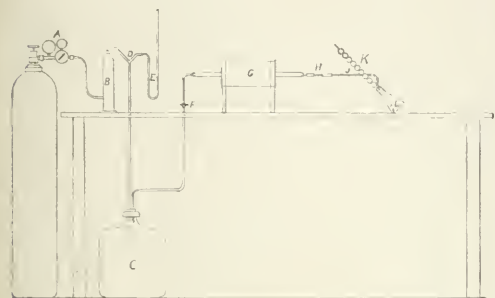


FIG. 2.—APPARATUS FOR DETERMINATION OF CARBON

Y-tube *D* as shown. The U-tube, which is connected to one leg of the Y-tube, contains enough mercury to fill it four inches deep. The third leg of the Y-tube leads into the equalizer, which must be clean and dry. A delivery tube terminating with a stop-cock *F* of either glass or brass, leads to each combustion furnace and train (only one is shown in the illustration). The equalizer may be a five-gallon bottle or any convenient gas-tight container. If a bottle is used the rubber stopper must be wired in. All connections must be made with high-pressure tubing.

After all the connections are made the stop-cock is shut and the oxygen is let into the apparatus until the difference in the level of the mercury in the U-tube is six inches. This serves as a pressure gage. The cock may then be opened, and the gas allowed to escape until it is reasonably certain that all the air has been replaced by oxygen. The apparatus may then be tested for leaks.

## COMBUSTION APPARATUS

There are a number of good electric furnaces for laboratory use giving a temperature of from 950 to 1100 deg. C. Combustion tubes of quartz or clay are in common use and may be obtained to fit the bore of the furnace.

Boats made of porcelain, quartz, alundum, clay or nickel may be used, but in any case the boat should be lined with a protecting layer of "RR" alundum, alkali free, specially prepared for carbon determination.

A plug of loosely packed asbestos fiber is placed in the outlet end of the combustion tube, together with a catalyzer of either copper oxide, platinized asbestos or platinum gauze. Some authorities maintain that a catalyzer is unnecessary, but its use gives a certain factor of safety. A temperature of about 1000 deg. is the best when no flux is used.

## THE TRAIN AFTER THE COMBUSTION APPARATUS

This consists of an orifice *H*, a delivery tube *J*, a 500-cc. Erlenmeyer flask *L* and a Meyer bulb *K* of special design. The bulb is about 45 deg. from the horizontal. A rack may easily be built for this purpose.

The orifice is made by heating the end of a piece of fairly heavy-walled glass tubing, with constant rolling, until it is nearly sealed. This makes a very small hole which lets the oxygen through at the desired speed. The time between turning on the oxygen and the instant the bubbling begins through the absorption bulb should be about twenty seconds. In other words it should take twenty seconds for the bulb to fill with the barium hydroxide. Following a little practice, the operator should have very little trouble in making these. It is necessary to put a filter of some sort (either a wad of cotton or asbestos) in front of the orifice to catch any ferric oxide which volatilizes while the steel is burning.

The great advantages of this apparatus are that it requires little attention. It is almost impossible for incomplete combustion to ensue due to insufficient supply of oxygen and because of this no difficulty is experienced in burning the sample without a flux at 1000 deg. C. All samples are tested under identical conditions, as the oxygen is always present and at a constant pressure.

## SOLUTIONS REQUIRED

**Barium Hydroxide.**—Dissolve 300 g. of barium hydroxide in 3 liters of hot freshly distilled water. (Put 100 g. in a liter flask or beaker and shake or stir frequently until solution is complete, except for a little precipitate of  $\text{BaCO}_3$  which is sure to form). Make this solution up to 19 liters with freshly distilled water in a 5-gallon bottle. After mixing thoroughly allow this solution to stand for at least 24 hours before using.

**Hydrochloric Acid.**—Dilute 151 cc. of concentrated hydrochloric acid to 19 liters with distilled water.

**Phenolphthalein Indicator.**—Dissolve 2 g. of phenolphthalein in 1000 cc. of alcohol.

## ACCESSORY APPARATUS

It is quite essential to have exactly the same volume of barium hydroxide for each determination. The best means of obtaining this is with an automatic overflow pipette of 80 cc. capacity. A 100-cc. automatic overflow burette may be used for the hydrochloric acid. The phenolphthalein solution is best introduced into the flask containing the barium hydroxide by means of a dropping bottle.

A very convenient way to wash the Meyer bulb is by means of a wash bottle, fitted with a syphon tube and clamp placed on a shelf over the train.

As it is desired to run the oxygen through the train for eight minutes, an eight-minute sand glass or any timing device will prove convenient.

A direct-reading scale is also convenient and may be made by determining the number of cc. for a two per cent carbon steel and measuring this distance on the burette. A draftsman can easily make a scale from these data so that every line will read to a hundredth per cent carbon when the zero or bottom of the scale is at the blank reading. This scale, drawn on a narrow strip of paper and inserted in a glass tube, may be fastened to the burette and adjusted at will by means of rubber bands.

The zero point is placed opposite the blank reading and the percentage carbon may then be read directly from zero up to 2 per cent carbon when a one-grain sample is used.

#### OPERATION OF TRAIN

Draw out 80 cc. of barium hydroxide into a 500-cc. Erlenmeyer flask. Connect this flask to the Meyer bulb immediately. The end of the Meyer bulb tube should reach to the bottom of the solution.

A blank is first run to determine the zero reading. After the flask containing the barium hydroxide is in place the train is connected by placing the stopper in the silica tube. The oxygen is then turned on and allowed to run for eight minutes. At the expiration of this time the oxygen is turned off, the Meyer bulb rinsed out with distilled water from the overhead wash bottle, and the end of the bulb and the sides of the flask washed. Five or six drops of phenolphthalein are added and the solution titrated to a faint pink with the standard hydrochloric acid which has been prepared as described.

If the solutions have been properly made, 80 cc. of barium hydroxide will be equal to about 85 to 86 cc. of the standard hydrochloric acid.

This reading is the zero point for the carbon determination. A standard steel from the U. S. Bureau of Standards, or its standard equivalent, must then be run to determine the factor. The blank reading minus the reading obtained by running the standard steel times 0.06 gives the percentage carbon in the steel if solutions are correct.

#### NOTES

The interval from the time the oxygen is turned on until the instant the bubbling begins through the Meyer bulb is about 25 seconds. This is controlled by the size of the orifice.

The barium hydroxide solution should be prepared as quickly as possible to minimize the precipitation of barium carbonate due to contact with the atmosphere. A guard tube containing soda-lime must be connected to the tube through which the air is admitted into the bottle of barium hydroxide to free the air from  $\text{CO}_2$ .

In titrating the barium hydroxide with the hydrochloric acid the flask containing the solution must be agitated continuously to prevent an excess of hydrochloric acid in one spot. If this is not done the hydrochloric acid will react with the precipitated barium carbonate and the results will be incorrect.

Blanks and standard steels should be run at least once every 24 hours, as solutions change slightly.

The description refers to only one train, but a number of trains may be attached to the equalizer and arranged according to the room available.

#### DETERMINATION OF CHROMIUM IN HIGH-SPEED STEEL

The following method for the determination of chromium in high-speed steel is simple and accurate.

#### SOLUTIONS

*Sulphuric acid*, sp.gr. 1.84, 1:3.

*Microcosmic salt*, 15 per cent solution is distilled water.

*Nitric acid*, sp.gr. 1.42.

*Silver nitrate*. Dissolve 5.28 grams of silver nitrate in 2 liters of distilled water.

*Ammonium persulphate*. Dissolve one pound of ammonium persulphate in 2400 cc. of distilled water.

*Hydrochloric acid*, sp.gr. 1.20, a 5-per cent solution.

*Standard ferrous ammonium sulphate*. Dissolve 57 grams of ferrous ammonium sulphate in 3000 cc. of distilled water and add 100 cc. of sulphuric acid sp.gr. 1.84.

*Standard potassium permanganate*. Dissolve 3.66 grams of potassium permanganate in 2 liter of distilled water.

#### METHOD

Dissolve one gram of the sample in 50 cc. of sulphuric acid (1:3) and add 40 cc. of 15 per cent microcosmic salt. When the steel is completely in solution, add 20 cc. of nitric acid, sp.gr. 1.42, and boil until free from brown fumes. To this solution add 50 cc. of the silver nitrate solution and 50 cc. of the ammonium persulphate solution and boil until the small bubbles of oxygen cease to be evolved; then add 15 cc. of 5-per cent hydrochloric acid and boil until the last trace of the permanganate pink is gone and then remove the flask to the cooling bath.

To the cold solution add 25 or 50 cc. of the standard ferrous ammonium sulphate, depending on the chromium content of the steel, and titrate the excess with the standard potassium permanganate to a permanent pink. A blank and a standard steel must first be run. Blank minus the titration multiplied by 0.1 equals the percentage chromium if the solutions are correct; if not, they must either be corrected or the factor established.

#### NOTES

Upon adding the nitric acid the tungsten present is converted to the soluble phosphotungstic acid.

As vanadium reoxidizes rather slowly, it is advisable to wait for at least 30 seconds to be certain that the correct end-point has been reached.

A 25-cc. automatic overflow pipette is best for measuring the standard ferrous ammonium sulphate.

It is advisable to keep the standard ferrous ammonium sulphate solution in the dark under the titration bench, and pump it into the pipette with a rubber bulb. The rubber tubing will also last longer under these conditions. A blank and a standard steel should be run every other day.

John A. Crowley Co., Detroit, Mich.

#### Ferro Alloys in Japan

Before the war all iron alloys, except a certain amount of ferromanganese, were imported from abroad; but lately a great many plants have been established for the preparation of many kinds of iron alloys. Ferro silicon, ferro chrome, ferro tungsten and ferro molybdenum are most important for the preparation of special steels. The following table shows the amount of such alloys formerly imported.

#### IMPORTS OF FERROUS ALLOYS

|                                                       | 1913<br>Tons | 1914<br>Tons | 1915<br>Tons |
|-------------------------------------------------------|--------------|--------------|--------------|
| Ferro silicon and silicospiegeleisen...               | 1,900        | 1,220        | 1,710        |
|                                                       | \$84,800     | \$85,400     | \$123,870    |
| Ferro manganese .....                                 | 4,500        | 1,300        | 2,950        |
|                                                       | \$257,000    | \$65,000     | \$212,000    |
| Spiegelisen .....                                     | 2,000        | 755          | 840          |
|                                                       | \$54,000     | \$22,000     | \$22,000     |
| Ferro chrome and all other non-malleable alloys ..... | 750          | 225          | 1,200        |
|                                                       | \$115,000    | \$43,000     | \$160,000    |

# Radioactive Luminous Materials

Sequence of Scientific Development of Research on Radioactivity Phenomena—Recent Technical Uses of Radium Luminous Materials—Adaption to War Needs

BY WALLACE SAVAGE

IN THE middle of the last century physicists were very much interested in the luminous phenomena produced upon the passage of electric sparks through rarefied gases. The gases were ordinarily enclosed in glass tubes into which platinum wire electrodes were fused at proper places. The Geissler tube was one of the simplest, being a straight tube bulbed at the center and cathode end and having a vacuum of a few millimeters of mercury. Upon the application of sufficient electromotive force, the discharge electrode (cathode) became surrounded by a mellow, deep-blue, luminous envelop, called the "glow-light." From the positive electrode (anode), a peach-red tongue of light extended almost through the entire tube. That these flames were negatively and positively electrically charged air particles was established by their being deflected by the respective poles of the magnet and by their mechanical properties—a small experimentally interposed wheel with mica paddles being rotated by the impact of the

of the arrested negatively charged air particles, which set up a high frequency vibration in the glass wall, which in turn effected the light bearing medium.

## DISCOVERY OF RADIOACTIVITY OF URANIUM

While following out Roentgen's X-ray discovery in its connection with the phenomenon of fluorescence and phosphorescence, Henri Becquerel made an as yet un-

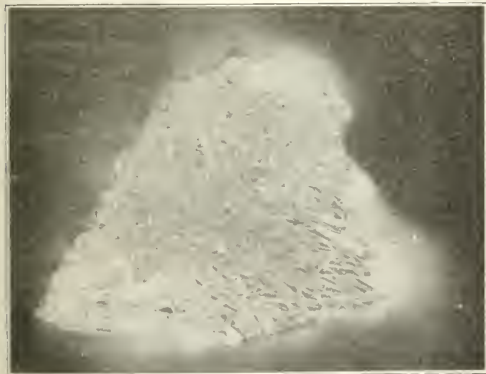


FIG. 1 RADIO-PHOTOGRAPH OF FERRO-URANIUM  
Courtesy, Standard Alloys Co.

stream. Upon absolute exhaustion of the tubes, no current was conducted, which verified further the mechanical nature of the phenomena.

In 1895, Roentgen surrounded one of these types of exhausted tubes (Hittorf's) with black light-opaque cardboard, and discovered that a fluorescent substance (barium-platino-cyanide) was made luminescent when current passed through the covered tube. To his astonishment he found that there were being emitted rays similar to light excepting in that only metals and mineral substances prevented their passage. He had discovered the X-ray, which was to become one of the greatest appliances in the practice of surgery. In subsequent investigations, it was established that the X-ray was produced at the glass wall of the tube by the impact



FIG. 2. RADIO-PHOTOGRAPH OF URANIUM STEEL

foreseen and equally important discovery—radioactivity in uranium. His custom was to expose a fluorescent substance to light action, then to register the lag of the glow by its effect on photographic plates protected from ordinary light. Exposed uranium acted on the plates and Becquerel believed he had established a relation between fluorescence and X-rays. Later he exposed a plate to uranium that had not been recently acted on by light. To his surprise, upon developing the plate, he found that he obtained the same effect as with the light activated uranium. Some permanent actinic effect was indicated. Fig. 1 is a photograph of ferro-uranium (U. 35.4 per cent) taken by its own light with 112 hours of exposure. The light portions indicate the richer uranium crystals. In Fig. 2, the effect of dilution can be seen, the sample being uranium steel (U. 7.74 per cent) photographed with the exclusion of all foreign light.

Mme. Curie, wife of the professor of physics of the Sorbonne, Paris, took up the radioactive investigation. In searching for other examples, she found that thorium exhibited similar phenomena, which were proportional to atomic properties. A given weight of uranium metal had the same activity, no matter whether it was combined as a chloride, bromide, sulphate or nitrate, foreign elements exhibiting no influence upon the activity. She then investigated pitchblende, from St. Joachimsthal, which is a natural uranium oxide with many other metals in association. Contrary to her expectations



from prior work, the radioactivity of this Austrian mineral was four times stronger than would be expected from its uranium content. This contradicted her conclusion as to the atomic relations of this phenomena and indicated that there must be some other associated element present that until now had not been identified.

The mineral was dissolved and the different groups of elements successively precipitated, each residue being tested for radioactivity. The lead group showed a noticeable actinic effect, which has been identified and termed radium G, radioactive lead (at. wt. 206).<sup>1</sup> The copper group was found to contain a member which



FIG. 3. QUARTZ EVAPORATING DISH WITH 0.007 OZ. OF RADIUM EXTRACT FROM 65 TONS OF URANIUM ORE

Mme. Curie named polonium. Actinium came down with the iron group. The essential part of the activity however was found in the alkaline earth group. Upon making the usual sulphate of barium separation, the activity was located entirely in this residue, the radioactive substance being apparently occluded by the barium sulphate. The latter was reduced with carbon in a retort, and the sulphide dissolved in muriatic acid. The radioactive element was further segregated by fractional acid crystallization, its bromine and chlorine salts being more insoluble than those of barium. The element, radium, was finally obtained pure enough to be thoroughly studied. Fig. 3 shows a quartz evaporating dish containing 200 milligrams (valued at \$24,000) of radium salts, which not only furnishes light for registering its own photograph but illuminates the label.

#### THE NATURE OF RADIOACTIVITY

Besides affecting the photographic plate through ordinarily opaque substances, radium ionizes gases—charges them with positive and negative electricity. Three physical phenomena have been identified and termed alpha, beta and gamma rays, of which the latter only is an actual ray. The alpha ray is a positively charged helium particle which is emitted meteor-like from the radium with a velocity of 20,000 miles per second. The beta ray consists of negatively charged electrons, having a mass of  $\frac{1}{6400}$  of that of helium and

a velocity approaching that of light—100,000 to 186,000 miles per second. The alpha particle is stopped by impact with an ordinary sheet of writing paper, while the beta particle is only arrested by metals. All evidence indicates that the beta particle is similar in its properties to the electron found in the X-ray tube, the cathode ray.

The gamma rays are not material in character but are vibrations in the ether. They are produced upon the impact of the beta particles on matter by the subsequent induced vibration which is transmitted to the ether. The elimination of the alpha and beta particles resembles an explosion within the radium. It has been determined that in 1700 years, radium will be half consumed in this disintegration phenomenon.

The greatest scientific interest has been aroused by the establishment of the fact that this disintegration radioactive phenomenon is actually a case of the transmutation of chemical elements. Table I gives the uranium to lead series<sup>2</sup> and Table II, the thorium to lead. The changes in atomic weight will be noted to be four, the mass of the helium X-ray atom removed.

TABLE I—THE URANIUM RADIOACTIVE SERIES

| Series                 | Half-Value Period       | Rays                      | Atomic Weight |
|------------------------|-------------------------|---------------------------|---------------|
| Uranium 1              | 5x10 <sup>8</sup> years | $\alpha$                  | 238           |
| Uranium X <sub>1</sub> | 24 6 days               | $\beta$                   | 234           |
| Uranium X <sub>2</sub> | 15 min.                 | $\beta$                   | 234           |
| Uranium 2              | 2x10 <sup>6</sup> years | $\alpha$                  | 234           |
| Ionium                 | 10 <sup>8</sup> years   | $\alpha$                  | 230           |
| Radium                 | 1690 years              | $\alpha$ $\beta$          | 226           |
| Radium emanation       | 3.86 min.               | $\alpha$                  | 222           |
| Radium A               | 3 min.                  | $\alpha$                  | 218           |
| Radium B               | 26.8 min.               | $\beta$ $\gamma$          | 214           |
| Radium C               | 19.5 min.               | $\alpha$ $\beta$ $\gamma$ | 214           |
| Radium D               | 16.5 years              | $\beta$ $\gamma$          | 210           |
| Radium E               | 5 days                  | $\beta$                   | 210           |
| Radium F               | 136 days                | $\alpha$                  | 210           |
| Radium G (lead)        |                         |                           | 206           |

TABLE II—THE THORIUM RADIOACTIVE SERIES

| Series                        | Half Period                | Rays             | Atomic Weight |
|-------------------------------|----------------------------|------------------|---------------|
| Thorium                       | 1.5x10 <sup>10</sup> years | $\alpha$         | 232           |
| Mesothorium 1                 | 5.5 years                  | $\beta$ $\gamma$ | 228           |
| Mesothorium 2                 | 6 2 hours                  | $\beta$ $\gamma$ | 228           |
| Radiothorium                  | 2 years                    | $\alpha$         | 232           |
| Thorium X                     | 3 65 days                  | $\alpha$         | 228           |
| Thorium emanation             | 54 sec.                    | $\alpha$         | 220           |
| Thorium A                     | 47 sec.                    | $\alpha$         | 216           |
| Thorium B                     | 10 6 hour                  | $\beta$ $\gamma$ | 212           |
| Thorium C                     | 1 hour                     | $\alpha$ $\beta$ | 212           |
| Thorium D                     | 3 1 min.                   | $\beta$ $\gamma$ | 208           |
| Thorium D <sub>2</sub> (lead) | 10 years                   | $\beta$          | 208           |

#### THE ALPHA PARTICLE LUMINOSITY

If radium salts are mixed with phosphorescent zinc sulphide, a permanently luminous yellow-colored material is obtained, the light of which is proportional to the radium content. It is found that the impinging of the alpha particles, which are individually visible under the microscope, sets up a vibration in the zinc salt which produces a glowing light. To withstand the perpetual bombardment of these 20,000-mile per second particles, especially strong crystals of zinc sulphide must be obtained.

These are manufactured by sublimation from an electric furnace, the zinc sulphide vapors are condensed in cooling chambers in a fine flour, similar to sulphur. The luminous paint usually carries from 10 to 25 mg. of radium element per 100 gms, depending upon whether a legible contrast glow is needed at the transition periods of day and night—however, too high a radium content is not desirable, on account of the inability of the zinc sulphide crystals to permanently withstand very concentrated impact shocks from the  $\alpha$ -ray without deteriorating.

<sup>1</sup>Prof. T. W. Richards, *Jour. A. C. S.*, Vol. 26, 1229 (1914); Vol. 38, 221, 1658, 2613 (1915); Vol. 39, 53 (1917); Vol. 40, 1403 (1918).

<sup>2</sup>Richard B. Moore, *Trans. American Ins. of Mining Eng.* No. 110, p. 1169.

## LUMINOUS VARNISH

Since the war, the Radium Co. of Colorado has established the Cold Light Mfg. Co. at 558 W. 158th St., New York. This latter company has equipped over half a million Marvelite dials on instruments now being used by our military forces. Fig. 4 illustrates an aeroplane altimeter as it appears in the day and night

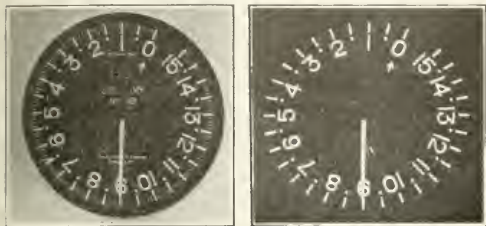


FIG. 4.—ALTIMETER DIAL, DAY AND NIGHT

when 9000 ft. above sea level. Fig. 5 shows a compass, clock and air speedometer. The extent of the military use of illuminated indicating devices may be surmised when upon examining an aeroplane, nine instruments are found so equipped. The civil engineers have found it an exceptional boon, for the spirit bubbles on their levels and transits and the marks on their tapes are made sufficiently visible for them to attend to their

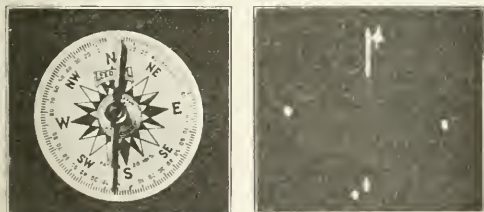


FIG. 5.—MILITARY COMPASS DIAL, DAY AND NIGHT. BELOW, AFROPLANE CLOCK AND SPEEDOMETER DIALS



surveys at night as well as in the day without raising any objection from the enemy. Gun sights are greatly aided by being touched up and night aiming is thus quickly accomplished, when a sudden flare exposes an enemy target.

On the sea, now that lights have to be extinguished because of the U-boats, the pilot has compass, log and all, self-illuminated. Radioactive celluloid sheets are now being manufactured from which FIRE ESCAPE, EXIT, electric push button indicators etc. are stamped. No

doubt many valuable applications will be found in engineering practice for this material as distinctive as the uses in "Hunotherapy."

## RADIUM SUBSTITUTE

Mesothorium is also being used for luminating zinc sulphide. Its half period as will be seen from comparing Tables I and II is much shorter than that of radium; however, for temporary dials on inexpensive watches, clocks etc. which are not expected to last longer than four or five years, its use is fully satisfactory. Mesothorium can also be used in cancertherapy.

## Enemy Technical Periodicals Available

Following the passage of the Trading-with-the-Enemy Act, the enemy publications committee of the American Library Association was granted a license by the War Trade Board, whereby universities, colleges, and public bodies of approved character might secure enemy publications of importance to research in science and scholarship, provided the Department of State approved the method and the Censorship Board sanctioned the admission of such material. Two hundred and fifty-five magazines have been approved by these bodies, and approved institutions may enter subscriptions for any of them through the secretary of the committee of the American Library Association, M. L. Raney, Johns Hopkins University, Baltimore, Md. The list of periodicals of interest to technical men here given is abstracted from the report of the committee:

## CHEMISTRY

*Annalen der Chemie.*  
*Chemisches Zentralblatt.*  
*Deutsche chemische Gesellschaft, Berichte.*  
*Journal für praktische Chemie.*  
*Kolloid-Zeitschrift.*  
*Zeitschrift für analytische Chemie.*  
*Zeitschrift für angewandte Chemie.*  
*Zeitschrift für anorganische und allgemeine Chemie.*  
*Zeitschrift für physikalische Chemie.*

## TECHNOLOGY

*Archiv. für Eisenbahnwesen.*  
*Archiv. für Elektrotechnik.*  
*Armierter Beton.*  
*Beton und Eisen.*  
*Die chemische Industrie.*  
*Deutsche Bauzeitung.*  
*Dingler's polytechnisches Journal.*  
*Elektrotechnik und Maschinenbau.*  
*Elektrotechnische Zeitschrift.*  
*Ferrum.*  
*Gesundheits-Ingenieur.*  
*Glückauf.*  
*Journal für Gasbeleuchtung.*  
*Metall und Erz.*  
*Der Oelmotor.*  
*Prometheus, Illustrierte Wochenschrift über die fort-*  
*schrötte in Gewerbe, Industrie und Wissenschaft.*  
*Rauch und Staub, Zeitschrift für ihre Bekämpfung*  
*Stahl und Eisen.*  
*Verein deutscher Ingenieure, Zeitschrift.*  
*Zeitschrift für Architektur- und Ingenieurwesen.*  
*Zeitschrift für Bauwesen.*  
*Zeitschrift für das ges. Turbinwesen.*  
*Zeitschrift für Elektrochemie.*  
*Zeitschrift für Instrumentenkunde.*  
*Zeitschrift für komprimierte und flüssige Gase.*  
*Zeitschrift für Transportwesen.*  
*Zeitschrift für wissenschaftliche Photographie.*  
*Zentralblatt der Bauverwaltung.*

It is impossible to secure these publications through any other source than that above indicated.

## Metallography and the War

BY ZAY JEFFRIES

CIVILIZATION is a human product. The utilization of the forces and materials of nature by man has brought about our modern industrial civilization. This has made possible the magnitude and intensity of the present war.

Just as metal has been one of the most important materials—historians pronounce it the most important—used by man in the evolution of our industrial civilization, it is also one of the most important materials used in modern warfare.

Metallography is the "science of metals" according to the Century Dictionary. Previously the term was used to apply only to the microscopic examination of metals, but in later years its scope has been extended to include the constitution of alloys, heat treatment, deformation, and the study of the properties of metals. The physicist or other scientist may perfect apparatus to measure hardness, high temperature, coefficient of expansion, electric and heat conductivity, or to study the positions of the atoms in a crystal, but when used to determine properties of metals for the purpose of producing uniform metal product, these become, like the microscope, tools of the metallographist.

### PRODUCTION OF METALS FOR SPECIFIC USES

The object in producing a metal or alloy is to fit it for use; its properties determine the utility. Metals require different properties in accordance with their use. For example, in a thermostat the chief property may be coefficient of expansion; in a thermo-couple, melting point or thermo-electric force; in a watch spring, resiliency; in an electric transmission wire, high electric conductivity; in a cutting tool, hardness; in a cannon, high strength coupled with resistance to shock; in an airplane part, high strength, coupled with low specific gravity; in acid vats, non-corrodibility; in armor plate, resistance to penetration, etc. For any purpose the metal having the desired properties and costing the least, should be used.

In the production of metals for specific uses, metallography plays two rôles:

1. The control of the manufacturing processes to obtain uniform products;
2. The development of new alloys or processes to serve specific purposes.

Metal parts used in machines and devices such as airplanes, automobiles, engines, cannon, shells etc. must be dependable. To be dependable the product must be uniform. It is much better to use a metal with an average tensile strength of 57,000 pounds per square inch with minimum and maximum 50,000 and 60,000 pounds per square inch respectively, than to use one with an average tensile strength of 75,000 pounds per square inch, but with minimum and maximum 40,000 and 110,000 pounds per square inch, respectively. Engineers must design with the minimum and not the average values in mind.

It is probably safe to state that owing to the pressing need for quantity production, the principal value of metallography in the production of war materials is in the control of processes which tend to make the products uniform. Of course uniformly good results are better

than uniformly poor results so it is to be assumed that the former is the goal. In the study and control of factors leading to the production of uniform product, the metallographist has many tools. The function of each tool is to enable one to determine some specific property of the material which will enable him to predetermine, at least to a certain extent, the utility of the metal part. This predetermination depends on the interpretation of laboratory tests in the light of past experience, the record of performance in use serving always as the absolute guide.

### IMPORTANCE AND LIMITATIONS OF THE MICROSCOPE

Of all of the places of apparatus used by the metallographist, the microscope is probably the most useful and at the same time the least satisfactory. It is the most useful because we owe to it our knowledge of the "proximate" composition of alloys and of the crystalline structure of single component metals. It is the least satisfactory because the examinations are largely qualitative rather than quantitative; too much now depends on the personal equation. Fortunately the present tendency is strongly toward quantitative microscopic examinations. Apparatus to determine hardness, critical points, strength, ductility, expansion etc. yield quantitative results in a large measure independent of the operator and to this extent they are satisfactory as well as useful.

The properties of any metal or alloy will depend on the nature and quantity of each constituent present, the properties of each constituent, and the arrangement of the constituents.

If some condition like the temperature or external pressure changes, then the properties of the metal or alloy will change in accordance with the change of properties of each constituent and the changes in quantity and arrangement of the constituents brought about by the changed condition.

The ultimate constituents are of course the electrons and atoms. If a line were drawn the width of 100 atoms, it would just be visible under the highest powered ultra-microscope. The smallest cube visible under the microscope would consist of more than a million atoms. The metallographic constituents capable of study under the microscope, therefore, must be confined to units larger than one million atoms. But owing to the wonderful developments of the modern physicist, the microscopist can think in terms of atoms even if he cannot see them. No doubt many of the unexplained variations in the properties of metals and alloys could be interpreted if we would extend our observations to the atoms rather than to groups of millions of atoms. The arrangement of the atoms involves the question of the arrangement of the constituents. The atoms of a crystal are arranged in a regular manner and of an amorphous substance in a haphazard manner. The difference in arrangement of the same atoms in the crystalline and amorphous states, produces a marked difference in properties. Internal stress in metals also involves a change of position of the atoms inasmuch as every stress is accompanied with a certain deformation or strain.

But in terms of what can be seen under the microscope, we are interested chiefly in those constituents which separate in relatively large masses. In pure



metals, solid solutions, and chemical compounds, so far as can be seen under the microscope, one constituent only is present. In other alloys more than one constituent can be seen. As the constituents vary in quantity the properties of the alloy change. With the same quantities of given constituents, the properties change in a marked degree with change in the arrangement of the constituents. A splendid example of this is found in 0.9 per cent carbon steel. In normal slow cooling there are two constituents, viz., ferrite about 86.5 per cent and cementite about 13.5 per cent. The cementite and ferrite are in the form of plates arranged in alternate layers. The elastic limit of the steel with this arrangement of the constituents may be over 50,000 pounds per square inch. With the same quantity of ferrite and cementite, the cementite can be spheroidized, that is, changed from flat plates to little spherical globules completely surrounded by ferrite, and the elastic limit may thus be reduced to 25,000 pounds per square inch.

The quantity and arrangement of the constituents of a given metal or alloy may be changed by heat treatment or by mechanical working. If the proper quantity of each constituent and the best arrangement for a given purpose are known, the microscope will aid in the production and control of the desired combination. It is necessary that the microscopist be able to identify the various constituents by means of the various etching and polishing treatments.

The use of metallographic apparatus in the development and control of metals for war materials is very extensive. Such companies as The American Steel & Wire Co., The Bethlehem Steel Co., The United Alloy and Steel Corp., The Halcomb Steel Co., The Carnegie Steel Co., The American Brass Co., The New Jersey Zinc Co., The National Lead Co., The Boston & Montana Copper Co., The Aluminum Co. of America, The General Electric Co., The International Nickel Co., and scores of other companies use up-to-date microscopic and other metallographic means of control in the manufacture of their metal products.

#### WAR USES OF METALLOGRAPHY

Most of the steel now being manufactured is used for war purposes. Many users of steel such as the large automobile and airplane manufacturers, railroad companies, manufacturers of tools, guns, shells, armor plate etc. control their products by metallographic methods. The various departments of the Government dealing with the use of metals also use metallography to control the quality.

In making cannon, the thickness of the metal section is such that longitudinal and transverse tensile tests can be made. These tests show general tendencies as regards the directional properties of the steel due to casting and forging. A rifle barrel, on the other hand, is so small that the longitudinal tensile test only can be made. The directional properties of the steel in a rifle barrel, therefore, are best indicated by means of a microscopic examination. Non-metallic impurities such as slag and manganese sulphide can be seen under the microscope, the relative quantities ascertained, and predictions can be made regarding the effect on the physical properties. In this manner the microscope is used in conjunction with tensile and hardness tests to

control the quality of steel used in rifle and machine gun barrels and other small fire arms.

The microscope is also used extensively for controlling the quality of brass and bronze. In brass the alpha and beta constituents can be differentiated, and the grain size ascertained. The grain size of brass is used generally to control the annealing operations. Metallographic control has aided greatly in the production of cartridge cases and other brass munition parts.

The arrangement and quantity of the various constituents in bearing metals as observed under the microscope enable one to predict the bearing properties better than any physical test outside a bearing test itself. While the application of the microscope in the control of bearing metals is not as extensive as it should be, its value has been recognized by several large companies, making bearings for machines to be used for war purposes.

#### NEW AND SPECIAL FIELDS FOR METALLOGRAPHY

Metallographic control methods are now used extensively on castings of iron, brass, bronze and aluminium. The study of the constitution of some of the aluminium alloys has aided greatly in the knowledge of their properties and control. A new feature has been developed within the last few years, viz., the heat treatment of aluminium. Some of its alloys have critical points and can be hardened and strengthened and at the same time be made more ductile by heat-treatment processes. Rolled aluminium alloys are made now having tensile strength of 55,000 pounds per square inch and 20 per cent elongation in 2 inches.

Another field for metallography is the development of new and better products. Just as the metallographist frequently makes important scientific contributions to physics and chemistry, so do workers in all branches of industry and science add to the sum total of metallographic knowledge and hence to the new developments. In fact, some of the new developments come from unexpected quarters. Sometimes the developments are the results of accident, but they are generally the result of scientific elimination. The science of elimination consists largely in the choice of the proper scope of materials and processes to produce a certain product and the elimination of all but the most suitable by planning experiments to study one variable at a time.

In this connection such men as H. M. Howe, Bradley Stoughton, R. R. Abbott and P. D. Merica are working practically their entire time on development problems in the United States. A. Sauveur is doing work in France for the United States Government along metal development lines. Many metallographists of England and France are engaged in the same kind of work for their Governments.

In addition to this many of the large industrial companies are carrying on research work to produce better alloy combinations and better treatments. In particular, great strides have been made in the production and treatment of special steels for aircraft-motor construction and for armor plate. The details of these developments probably will not be made public until the close of the war. Only when the details are made public can the magnitude and importance of this development work be adequately appreciated.

Cleveland, O.

## Chemical Iron Ware

### A Description of the Silicon Irons—Acid-Resisting, a Relative Term—Comparative Action of Corrosives—Acid Resisting Castings

RECENTLY considerable controversy has arisen in England over a paper read by Professor Camille Matignon before the Academic des Sciences of Paris<sup>1</sup> on his investigations of various commercial alloys of ferrosilicon. Starting his investigation in 1913, at the very start of the commercial development of this industry, Dr. Matignon had great difficulty in getting samples, so that his report probably did not represent simultaneous comparisons of the various products.

Considering the rapid developments being made in this field, no report less than present day comparisons is of value. Several concerns are manufacturing this type of chemical ware in America. The compositions of six of the alloys analysed by Dr. Matignon are reported as follows:

|            | Métallure | Elianite I | Elianite II | Ironac | Duriron | Ferroboron |
|------------|-----------|------------|-------------|--------|---------|------------|
| Si.        | 16.92     | 15.07      | 15.13       | 13.16  | 15.51   | 4.9        |
| Fe.        | 81.05     | 82.40      | 80.87       | 83.99  | 82.23   | 69.8       |
| Mn.        | 0.88      | 0.62       | 0.53        | 0.77   | 0.66    | 3.3        |
| Ni.        | .....     | .....      | 2.25        | .....  | .....   | .....      |
| Al.        | 0.25      | .....      | .....       | .....  | .....   | 3.1        |
| C.         | 0.592     | .....      | 82          | 1.08   | 0.83    | .....      |
| P.         | 0.173     | .....      | 0.06        | 0.78   | 0.57    | .....      |
| S.         | 0.01      | .....      | 0.03        | 0.05   | 0.01    | .....      |
| Ca and Mg. | .....     | .....      | .....       | .....  | .....   | 15.4       |
| B.         | .....     | .....      | .....       | .....  | .....   | .....      |

The following are extracts from *Engineering*, Vol. CVI, pp. 154-156, Aug. 9, 1918, giving a full account of tantiron. While it does not pretend to offer a comparison of the several products, it shows the present state of this industry in England and America.

The manufacturing chemist and metallurgist are greatly restricted by the limitations of applicability of their apparatus. In many processes, the difficulty is not so much to obtain the raw materials as to find furnaces, containers, pipes etc., that will bear the chemical and physical stress of the reactions, and to avoid the contamination of the products by the substances with which the reactions bring them into contact. For these reasons many a promising process never gets beyond the laboratory stage; hence, also, the cry for substitutes of rare, expensive materials, as well as the natural distrust of them. The enhanced activity of certain chemical industries has much increased the demand for refractory materials and acid-resisting alloys. Experiments with acid-resisting iron alloys are not new, of course. Wollaston made a silicon-iron, and he may not have been the first. Engineers and electricians found silicon-iron very useful for special purposes, and many attempts were made to construct chemical plant of silicon-iron and other iron alloys. Tungsten, chromium and nickel were tried. But foundrymen seemed to be unable to make vessels even of moderate dimensions of such materials, and it was not till 1912 that an acid-resisting iron alloy of sufficient uniformity and strength for the engineer to deal with was put on the market.

It was the tantiron of Mr. R. N. Lennox, made by the Lennox Foundry Co. of Glenville Grove, New Cross, S. E. Since then silicon-iron and other non-corrosive iron alloys have been brought out by several firms. Both the "duriron" of the Duriron Castings Co. of Dayton, Ohio, and the "ironac" of the Houghton Co. of London, are silicon-irons, like the métallures of A. Jouve, one of the first in this field, and the Italian elianites, which contain about 2 per cent of nickel. The American rights for tantiron were taken over in 1913 by the Bethlehem Foundry and Machine Co., Pennsylvania. "Ferrochrome" is supplied by the Electrometallurgical Co. of Niagara Falls; the "feralun" is likewise an American product, and German activity in the field will not have ceased during the war; in addition to "neutraleisen," there are ferro-chromes and ferro-borons.

#### ACID-RESISTING IS A RELATIVE TERM

Tantiron is a silicon-iron, containing about 15 per cent of silicon. In appearance it is a silvery-white close-grained cast-iron, and has the general properties of a machinable cast-iron. One special brand of tantiron is very hard, and not machinable; another quality resists hydrochloric acid which the others do not. It melts at about 1200 deg. C., can be cast, ground with carborundum, cut with the saw, drilled, screw-cut and tapped etc. Sofar as chemical and mechanical corrosion is concerned, it is a superior iron and is used for cast vessels or in the shape of linings for those of steel or iron. It does not rust, except at the skin, and the rust is removed by pickling in diluted sulphuric acid or by grinding. The tantiron itself is not—or practically not—attacked by sulphuric, nitric, or acetic acid, concentrated or diluted, boiling or cold, and indeed not by most chemicals. One kind already mentioned—a more recent invention—also resists hydrochloric acid equally well. Carbonic acid attacks it slightly, but the corrosion is only about one-thousandth that of cast-iron. Alkalis corrode it about as much as they do cast-iron; chlorates and perchlorates do not corrode it, and it will resist chlorine gas up to a temperature of 105 deg. C. But sulphur dioxide corrodes tantiron badly. In view of this latter fact, the suitability of tantiron pans and basins for the concentration of sulphuric acid is rather surprising. Large pans have been in use, however, we are informed, since 1912, and some 25,000 basins are actually in use in sulphuric-acid works. There is some slight corrosion, of course, and there are breakages, partly due to the material, partly to improper treatment by unskilled labor, which causes many small and large accidents in these days of rapid plant erection and high-pressure activity. The maintenance cost of pans and basins is about 2½d. or 3d. per ton of acid concentrated. After boiling 100 grams of the alloy for

<sup>1</sup>Comptes-Rendus de l'Académie des Sciences, Vol. 166, pp. 815-818, May 21, 1918

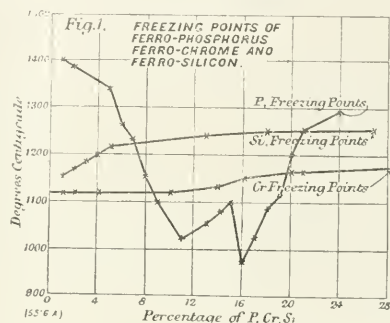
17 hours, 10 per cent sulphuric acid was found to have dissolved 0.13 gram of tantiron, 25 per cent nitric acid 0.25 gram, and 30 per cent hydrochloric acid 0.16 gram.

The term "non-corrodible and acid-resisting iron" is misleading, as all such general terms are. Every chemist knows that he must not allow metals to glow in his platinum crucible, as they would form fusible platinum alloys, and that caustic alkalis and certain alkali salts, and even the sooty flame of the gas burner, will ruin his crucible. Tantiron also has its peculiar weaknesses. It resists hot sulphuric acid much better than cold acid, and many instances of attack are so far inexplicable. In one case, a tantiron tower containing vapors from boiling sulphuric acid showed defects in the top sections, without any attacks on the bottom sections. The top sections were replaced several times; the bottom sections, which had been in use for eighteen months, were taken out and inserted in the top, when they were attacked within a fortnight; yet temperature determinations at different points of the tower never showed differences exceeding 5 deg. C. In other cases, supply missing part sulphuric acid, are being carefully freed from arsenic by sulphuretted hydrogen, attacked the tantiron nearly three times as quickly as the original acid. But the amount of attack is, of course, exceedingly small. A tantiron vessel weighing 4950 grams had 600 tons of sulphuric acid passed through it during concentration with a total loss of weight of 12 grams. The attack is namely on the surface or skin, which should, therefore, be removed when corrosion tests are conducted.

#### CHEMICAL COMPOSITION AND PHYSICAL PROPERTIES OF TANTIRON

Though the iron carbide seems chiefly to be attacked, the corrosion is apparently uniform; under the microscope, acid-corroded tantiron keeps its smooth surface, while cast-iron shows irregular corrosion. Mr. Lennox prefers to have no carbon in the iron at all. His raw materials are cast-iron, scrap, and old tantiron, and further ferro-silicon. The latter is obtained with about 12 per cent silicon from Middlesborough, and in a 50 per cent grade from Norway. The average composition of tantiron is in per cent: Silicon, 14 or 15; total carbon, from 0.2 to 0.6; manganese, 0.25 to 0.35; phosphorus, 0.16 to 0.20; sulphur, under 0.05. The three kinds mentioned, machinable tantiron, hard tantiron and tantiron for hydrochloric acid, differ little in composition, but the small fractions of additional constituents are very important. To study their influence, ingots are poured from furnace charges of 1 ton, to which additions are made in very small increments; the ingots are then tested chemically and mechanically. The sulphur and manganese, in their percentage, seem to be of no consequence. The phosphorus is deleterious, mainly probably because it is not uniformly distributed, but concentrated in spots. As phosphorus is added to iron, the freezing point is first lowered, and then, when 10 per cent of phosphorus is exceeded, rises again, but the cooling curves are not regular, while the freezing point curves of silicon-iron and chrome-iron show a very slow but steady rise with increasing percentages of those elements. (See Fig. 1.) Impact tests are made

on  $\frac{3}{8}$ -in. square bars, which are not notched; they break, e.g., under stresses of from 8 ft.-lb. to 10 ft.-lb., against 12 ft.-lb. to 14 ft.-lb. in the case of cast iron. On the whole, the strength of tantiron is about 25 per cent less than that of cast iron. The following is a summary of the comparative properties of tantiron and cast iron (the latter figures in brackets): Density, 6.8 to 7.0 (7.3); tensile strength, 6 to 7 (9 to 10) tons per sq. in.; transverse strength, bars of 12 in. by 1 in., 1600 lb. (2500 lb.); crushing strength per inch tube, 34 (40) tons; melting point, 1200 (1500) deg. C.; hardness, 1.6 (1); heat conductivity, 8 (10); electrical resistance, 10 (8); resistance to corrosion, 1000 (1); contraction allowance in casting,  $\frac{3}{16}$  ( $\frac{1}{8}$ ) in. per ft. As regards



other properties, also of other materials, the comparative order for iron, tantiron, lead, quartz, and stone-ware is: Transmission of heat, 230, 215, 115, 28, 20; hardness, 24, 35, 1, 52, 32; density, 7.3, 7, 11.3, 2.6, 2.0; melting point, 1150, 1200, 335, 1900, 1800 deg. C.

#### COMPARATIVE ACTION OF CORROSIVES

With respect to corrosion by chemicals, there is generally a first attack, followed by relative immunity under continued exposure. The following figures indicate the percentage losses of tantiron after boiling for 24, 48, 72 hours; the greater action during the first 24 hours is largely due to the already-mentioned skin effect, the outer surface having been changed by contact with the sand in which the tantiron is cast; this skin is removed in the foundry, as we stated.

|                              | First<br>24 Hours | Second<br>24 Hours | Third<br>24 Hours |
|------------------------------|-------------------|--------------------|-------------------|
| Sulphuric acid, 98 per cent  | 0.10              | 0.02               | 0.02              |
| Sulphuric acid, 30 per cent  | 0.07              | 0.00               | 0.00              |
| Nitric acid, 1.4             | 0.03              | 0.01               | 0.00              |
| Nitric acid, 1.1             | 0.01              | 0.00               | 0.00              |
| Acetic acid, 60 per cent     | 0.03              | 0.01               | 0.00              |
| Chromic acid, 10 per cent    | 0.07              | 0.00               | 0.00              |
| Tartaric acid, 25 per cent   | 0.05              | 0.03               | 0.03              |
| Iodine (sat. sol.)           | 0.00              | 0.00               | 0.00              |
| Bromine water (sat.)         | 0.01              | 0.01               | 0.00              |
| Bleaching powder (sat. sol.) | 0.04              | 0.01               | 0.01              |
| Copper sulphate (acid sol.)  | 0.00              | 0.00               | 0.00              |
| Copper sulphate (alkaline)   | 0.00              | 0.00               | 0.00              |
| Ferric sulphate (acid sol.)  | 0.06              | 0.00               | 0.00              |
| Zinc chloride, 30 per cent   | 0.03              | 0.00               | 0.00              |
| Ammonium chloride sol.       | 0.05              | 0.02               | 0.01              |
| Fused sulphur                | 0.06              | 0.01               | 0.00              |
| Fused nitrate of ammonia     | 0.00              | ...                | 0.00              |

To meet the peculiarities of the material, it is desirable that designers of parts to be made in tantiron should bear the following rules in mind: large flat surfaces should be avoided; corners be rounded; slots be used by preference to bolt holes; facing strips be narrow and of ample height; the effects of expansion and contraction should be well-considered: coreing and



moulding be made easy, by preference without the use of chaplets to support cores. Among the chief products now made wholly or partly of tantiron are acid pans, basins, stills, bleachers, denitrating towers, autoclaves, condensers, pumps, stop cocks, valves, pipes and fittings, electrodes etc. Frequently a tantiron lining will suffice to prevent either chemical or mechanical erosion. The largest tantiron casting so far constructed weighed 7½ tons.

The greatest care is bestowed upon clean moulding, which is mostly done by women, and use is made of rotating strickles in preparing the moulds for parts of circular section. For lining pipes with a tantiron, the pipe must be suspended vertically by a flange with the core in proper position, the pipe to be lined being weighted below; if the liquid tantiron were poured into a horizontal pipe, the pipe would curve. This practice is generally adopted for lining iron or steel, wherever possible, and the part to be lined is well dried, but not pre-heated. The adhesion between the iron and the tantiron is said to be good fusion taking place between the surfaces; the adhesion is tested with the acid of paraffin oil. The lining may have a thickness from ¼ in. up to 1½ in. and more. The subsequent finishing of the product is largely done with the aid of carborundum wheels and grinders. It is rather curious that the fine tantiron particles torn off by the tools do not spark; there is only a glow. Drills, saws and planers are also used.

#### ACID RESISTING CASTINGS

The basins for the heating and concentration of sulphuric are mostly of the plain porcelain dish style, but are provided both with a lip and an arc-shaped baffle (not shown); they are supplied also in the Webb and

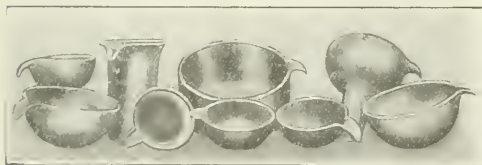


FIG. 2.—CASCADE ACID CONCENTRATING BASINS

Dyson styles (Fig. 2). The basins are arranged in cascade, so that the hot acid drips from the lips of one basin into the one next below, and the baffle prevents the acid from streaming right over the basins to the lip. Provisions for more efficient circulation and stirring of the acid in the basin is made in the "Mackenzie field tube evaporator basins," also supplied by Mr. Lennox; this style has calix shape, being a tube opening out into a basin; a "field" tube fits concentrically into the cylindrical portion and promotes active circulation. Other basins are provided with covers and necks, and made corrugated, and they serve generally also for the concentration of corrosive liquids, such as zinc chloride, lead nitrate, etc.

The concentration of nitric acid requires more varied apparatus, which have successfully been made of stoneware in the past few decades. When the war broke out, the stoneware works of this country were not able to deal with the demands, and tantiron vessels, which

can be made in a few days, while good stoneware requires months, were largely adopted. Valentiner plants comprising a still, condenser and coils, built up of pipes and return bends flanged together, all of tantiron, are now made. The denitrating tower illustrated in Fig. 3 is an interesting novelty. The spent acid of nitroglycerin works consists of diluted sulphuric acid, which has to be concentrated again, and some nitric acid, which is to be regained by distillation. There may also be small globules of oily nitroglycerin which might coalesce if the evaporation were carried on in pans. The tower, 15 ft. high, is built up of socket pipes, 14 in. in diameter, and is packed with quartz fragments; the acid enters at the top and steam at the bottom, and the nitric acid and vapor condense in the cylinder by the side of the tower. Nitric-acid stills are also used for the distillation of acetic acid. The autoclaves for making ammonium nitrate from cyanamide at a temperature of 120 deg. C. and a pressure of about 2 atmospheres resemble one style of nitric acid retorts. The outer vessel is a jacket of cast iron, the inner vessel of tantiron forms the saturator; the height is 8½ ft., and the diameter 4½ feet.

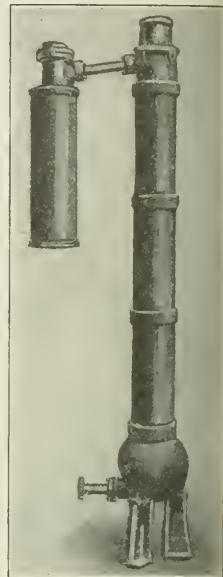


FIG. 3.—DENITRATING TOWER

Acid eggs, apparatus for forcing up corrosive liquids with the aid of compressed air, are made of two tantiron cups, joined by their top flanges so as to form a horizontal cylinder with spherical ends and one common flange on the vertical middle plane; they are provided with acid inlet and outlet valves and an air pipe, and are supplied in large sizes. The pumps of the works, reciprocating and centrifugal, do not differ much in appearance from ordinary pumps; the barrels and impellers and pipes are made of tantiron or lined with it. As these parts of hard tantiron cannot be machined or repaired, it is recommended to keep spare parts ready for cases of accident. Centrifugal pumps are supplied for lifting 6000 gals. of acid or corrosive water, etc., per hour, against a head of 50 ft., running at 1600 r.p.m. Slime pumps for conveying the crushed quartz in gold mines are likewise made of tantiron, to obviate the heavy erosion of the pipes by the gritty quartz particles. For the same reason, tantiron-lined steel pipes are used in the Rand mines, South Africa, for the sand-filling plant. When the pillars left in the galleries below are to be removed, the galleries have to be refilled with the finely crushed quartz from the vast white waste mounds which form a conspicuous feature of the district. The spoil is flushed down the pipes with water. The first pipes used, steel pipes, were ruined

by 6000 tons of sand; porcelain-lined pipes were then tried, which could stand up to 50,000 tons; the tantiron pipes, introduced four years ago, are still doing duty, and their life capacity is estimated at 500,000 tons. Similarly-lined steel pipes and tantiron pipes, up to 2 ft. in diameter, are in use for ash ejectors, especially on board ship where heavy erosion and corrosion by the caustic ashes and the sea water have to be guarded against.

In stop cocks and valves of tantiron, corrosion by acid sodium bisulphate (the acid cake residue of the distillation of nitric acid from salt and sulphuric acid) erosion by grit, rusting and sticking are the chief sources of trouble to be met. Here, again, tantiron completes with lead and stoneware, and its advantages lie in greater strength and indifference to high temperatures and frost. A great variety of cocks, valves, T-pieces, straight and bent socketed pipes, provided with threads, are made in tantiron.

Of other specialties, we mention the corrosive-vapor drying and baking ovens, the flat doors and walls of which are lined with sheets of tantiron, which are screwed on. Tantiron can be rolled at about 700 deg. C., but is brittle then. Another specialty is the tantiron electrode for cyanide baths (silver and gold), and also copper baths etc., replacing iron and other alloy electrodes, which are not insoluble, and very objectionable on this account, or more expensive than tantiron. For the same reason, steel-mixing mills for the manufacture of manganates, the balls and stirrers of other mills, and many apparatus used in the acid and dye and other chemical industries, are made of tantiron.

Like every manufactured article, tantiron is constantly being improved, and does not claim to have reached final perfection. Acid-resisting materials must possess various properties which are not easily combined, and possibly not capable of combination. A compromise has to be accepted.

## Ulco Hard Metal

By FRANCIS C. FRARY AND STERLING N. TEMPLE

THE development of this new hard-lead alloy may be considered as a by-product of the war and also of the Atlantic City meeting of the American Electrochemical Society. At the time of this meeting, in the spring of 1915, the heavy demand had raised the price of antimony to some seven times its normal value, and the larger consumers were naturally looking for substitutes. Mr. H. B. Coho, formerly chairman of the New York Section of the American Electrochemical Society, in talking with one of the authors at that meeting, mentioned the need of a substitute for antimony in hard lead, suggesting cerium, and explaining the interest which the United Lead Co., with which he was connected, had in such an alloy.

It so happened that in the work done by Frary and Badger<sup>1</sup> on the production of metallic calcium, one lot of lead-calcium alloy had been made, and the fact noted that it was harder than lead. Calcium being easier to produce than cerium, it was considered a better starting point for experimental work. But when the calcium-

lead alloys were studied we found that a considerable amount of calcium must be used in order to get a hardness approaching that of antimonial lead (17 Brinell), and that this alloy did not stand remelting but easily lost its calcium. Upon making up similar alloys of lead with other metals of the alkaline earths, it was found that each hardened lead to a different but marked degree. Further experimentation brought to light the surprising fact that if two or more of the metals were used together, the hardening effect was several times that which would have been found if only one were present in the same total quantity, thus making it possible to produce an alloy which was harder than antimonial lead, but contained so little alkaline earth metal that it could be remelted several times without losing appreciably in hardness, and actually contained well over 99 per cent lead.

### METAL IS HARD AND CASTS FREE FROM BLOW HOLES

The rights to this alloy (U. S. Patents 1,158,671 to 1,158,675 inclusive, and corresponding foreign patents) were acquired by the United Lead Co., who proceeded to install a plant at Keokuk for its manufacture. The surprising toughness of the metal, the possibility of making it much harder than any other commercial lead alloy (some samples have been made which were as hard as steel) and the fact that it made castings entirely free from any trace of blow-holes and expanded to fill a void, like type-metal, made both the inventors and the company feel that it would have a useful function to perform, even though, in the mean time, the price of antimony had dropped to a point where the new alloy could scarcely compete for ordinary uses.

### TEST BY BUREAU OF STANDARDS

These hopes have been fulfilled and the alloy has taken its place among the important bearing metals, its high melting point, excellent structure and low coefficient of friction giving it a unique importance. The following report of tests from the U. S. Bureau of Standards confirms in an official way the experience of a number of firms who have experimented with it:

A 10-lb. ingot of the Ulco Hard Metal, the original Brinell hardness numeral of which was 25.2 at a load of 500 kg., was melted down, and chilled castings were poured at various temperatures with the following results:

| Temp.,<br>Deg. F. | Temp.,<br>Deg. C. | Brinell<br>Hardness<br>Numeral |
|-------------------|-------------------|--------------------------------|
| 650               | 343               | 23.5                           |
| 700               | 371               | 25.1                           |
| 750               | 399               | 25.0                           |
| 800               | 427               | 25.7                           |
| 900               | 482               | 27.8                           |
| 1,000             | 538               | 22.0                           |

The metal was fluid at 650 deg. F., and though the maximum hardness was produced by pouring at a temperature of about 800 deg. F., the hardness was not greatly reduced by pouring at higher temperatures.

Test bearings were then poured and service tests made in an Olsen testing machine, tests on genuine babbit being made at the same time to serve as a basis for comparison. The table below gives the results of these service tests:

| GENUINE BABBIT |                                |                            |                   |                          |                  |                 | Friction<br>in<br>Weight<br>Grams |
|----------------|--------------------------------|----------------------------|-------------------|--------------------------|------------------|-----------------|-----------------------------------|
| Load<br>lb.    | Total<br>No. of<br>Revolutions | Final<br>Temp.,<br>Deg. C. | Temp.,<br>Deg. F. | Rise in Temp.<br>Deg. C. | Temp.<br>Deg. F. | Friction<br>lb. |                                   |
| 100            | 694                            | 89                         | 192               | 53                       | 95               | 22              | 0.023                             |
| 200            | 706                            | 102                        | 216               | 58                       | 104              | 29              | 0.021                             |
| 300            | 682                            | 125                        | 257               | 100                      | 180              | 38              | 0.015                             |
| 400            | 603                            | 159                        | 282               | 94                       | 169              | 79              | 0.054                             |

(a) Belt slipping. (b) Bearing seized and smoking

<sup>1</sup>Transactions, Amer. Electrochem. Soc., 16, 155 (1909).

## ULCO HARD METAL

|       |     |        |    |     |    |    |    |           |
|-------|-----|--------|----|-----|----|----|----|-----------|
| 100   | 710 | 13,160 | 56 | 133 | 23 | 41 | 13 | 0.013     |
| 200   | 715 | 18,870 | 69 | 156 | 33 | 59 | 18 | 0.021     |
| 300   | 719 | 18,830 | 80 | 176 | 42 | 76 | 27 | 0.013     |
| 400   | 711 | 17,310 | 81 | 178 | 43 | 77 | 23 | 0.022     |
| 500   | 723 | 17,660 | 79 | 174 | 43 | 77 | 25 | 0.014     |
| 600   | 692 | 14,960 | 84 | 183 | 45 | 81 | 24 | 0.021     |
| 700   | 648 | 24,520 | 62 | 144 | 38 | 68 | 24 | 0.020     |
| 800   | 365 | 12,870 | 53 | 127 | 20 | 36 | 23 | 0.010     |
| 900   | 408 | 22,300 | 59 | 138 | 22 | 40 | 24 | 0.015     |
| 1,000 | 405 | 23,200 | 66 | 151 | 36 | 65 | 22 | 0.014 (a) |

(a) Bearing still in good condition.

The Ulco Hard Metal bearing was still running excellently at 100 lb. per sq.in. load, but as the capacity of the testing machine was reached the bearing could not run to failure, as in the case of the genuine babbitt bearing.

It will be noticed that the Ulco Hard Metal ran considerably cooler than the genuine babbitt, the friction was less and the wear also a smaller amount. It should be borne in mind that the specific gravity of the Ulco Hard Metal is much greater than that of genuine babbitt, and for equal loss in weight the volume loss would be less in the case of Ulco Hard Metal.

These tests were repeated on new samples with substantially the same results as above. A test was also made in which no lubricant of any kind was used in the bearing. The bearing was run at a speed of 700 r.p.m. and 50 lb. per sq.in. pressure, and after about 10 min. the metal began to flow and adhere to the steel shaft, scraping out more of the metal from the bearing. The shaft was not injured in the least by the test, and the metal that had adhered to it could be readily removed with a knife.

Tensile tests on Ulco Hard Metal and genuine babbitt cast under similar conditions gave the following results:

|                 | Tensile Strength, Lb. Sq.In. | Elongation, Per Cent in 1 In. | Reduction of Area, Per Cent |
|-----------------|------------------------------|-------------------------------|-----------------------------|
| Genuine Babbitt | 10,600                       | 15                            | 8                           |
| Ulco Hard Metal | 13,000                       | 5                             | 1                           |

The fracture of the babbitt showed blow-holes, reducing section approximately one-fourth, though the Ulco specimens were sound throughout. The average elastic limit in compression of Ulco hard metal was found to be 11,525 lb. per sq.in.

## ALLOY RESEMBLES LEAD IN MANY RESPECTS

The alloy has the general appearance of lead, may be cast, drawn, rolled or extruded; its specific gravity and melting point are practically identical with those of lead, and its composition so nearly the same that two analysts reported it as (1) commercially pure lead, (2) pure lead, heat treated. It may be diluted with ordinary lead to produce alloys which are not so hard, and tin and bismuth may be added if desired, but if more than a very small amount of antimony be added, the alkaline earth metal separates out and the alloy is ruined. It has the metallic ring of bell metal, and none of the brittleness of antimonial lead.

One of its peculiar properties which will doubtless interest metallographers is its pronounced increase in hardness upon standing or aging, and the possibility of accelerating this process by aging at steam heat. It is a fact not generally known or noticed that antimonial lead increases slightly in hardness for a few hours after casting, but the amount of this change is not large. With the lead-alkaline earth alloys, however, the fact was noticed early in the experimental work that all samples increased markedly in hardness for some time after being cast, so that it was entirely impossible to determine the hardness of the alloy until it had aged several days. Figures obtained in the research laboratories of the United Lead Co. show that an alloy with the Brinell number of 8 increased to 10 on standing a day, another with an initial hardness of between 13 and 16 reached 17.6 after standing two days, 19.6 after

standing eight days, and 20.7 after fifteen days. A part of the same sample, after being aged one day at 100 deg. C. had attained a hardness of 25.4.

## SOLID SOLUTION OF ALKALINE-EARTH METALS IN LEAD

Bars of the metal which have been cast in an iron mold and broken seem to show a slight difference in fracture which would indicate a chill effect at the surface which was in contact with the iron. The main body of the bar will exhibit a fine hackly fracture, like an alloy steel,



FIG. 1.—SECTION FROM A PIECE OF ULCO LEAD SHOWING FRACTURE

but a more distinctly crystalline structure appears for a depth of about  $\frac{1}{16}$  in. from each surface which was in contact with the mold. The effect is absent at the surface which formed the top of the ingot. Such metallographic work as has been done upon the alloy has not, as far as we are aware, developed any definite structure, and everything seems to indicate that we have to deal with a solid solution of the alkaline-earth metals in lead. This is true only for alloys containing small amounts of the alkaline-earth metals such as Ulco Hard Metal; these are stable toward water and have no taste, while alloys with several per cent of the metals break with a coarser structure and have the "electrolytic" taste with which everyone is familiar who has tried to test a dry battery by taste.

The possibility of using this alloy to replace babbitt and thus save tin for war uses is of course very important now, and its superior quality would indicate that such a substitution would not be disadvantageous. It has also found a field in the manufacture of various small castings; bath-room supply and waste pipes, nickel-plated, are at present made from it, and its hardness combined with ease of casting should recommend it for various other small castings, now made of brass.

Tin Mining is very profitable in Bolivia at present prices. The Llallagua Tin Co. made a gross profit of eight and one-half million dollars in 1917, which is about four times that of the year previous. Their production of ore concentrates increased from 7460 long tons in 1916 to 11,250 tons last year. The mine showings are figured at 261,902 tons; averaged at 14.33 per cent, they are estimated to offer 37,500 tons of metallic tin.



## Magnesium

### Some of Its Present Commercial Applications

**M**AGNESIUM, the lightest of commercial metals, was little known and little used in this country before the outbreak of the war in 1914. Prior to that time a small amount of this metal was imported in powder form for flash-lighting, and a few manufacturers used it in stick form with the metals.

The withdrawal of the German product from the market necessitated the development of its manufacture in this country to supply the existing demands. Allied purchases in the United States and our own entrance into the war have stimulated the production to a marked degree, on account of its use for flares and illuminating bombs of all kinds. Government bulletins show an increase in production in the United States, from 75,400 lb. in 1916 to 115,800 lb. in 1917, and to 116,938 lb. in the first six months in 1918.

Magnesium is a common element in many minerals occurring in America so that its production, like that of aluminium, can be increased to meet almost any demand. All that is necessary is to develop our water power, as cheap power is essential to the production of this metal. This possible future development is vital to those who are now using magnesium and to others who are contemplating its use.

We are today only learning how to use metals, and the future of the metal industry, in the application of alloys to various uses, will be like rubbing Aladdin's lamp. The future uses of magnesium may be as large a factor in revolutionizing industry as aluminium has been. Magnesium, however, cannot be said to be a competitor of aluminium; it is a co-worker with that metal. In other words, where it will replace aluminium in one industry, it will create a much greater use for it in others.

Magnesium in aluminium is, then, one of the present commercial uses. The first action of magnesium in aluminium is as a deoxidizing agent. At the temperature of molten aluminium, magnesium will reduce carbon monoxide and carbon dioxide, gases which are readily dissolved in molten aluminium and which cause endless trouble in cooling. As a result of its deoxidizing properties, it makes aluminium castings more dense.

All of the magnesium introduced into aluminium is not consumed in deoxidizing, and the resulting alloy is a much improved metal. As an alloy, magnesium makes aluminium stronger and gives it a finer grain. In addition to this it improves its machining qualities.

While all of these qualities are obtained with  $\frac{1}{2}$  per cent. an increase in the amount of magnesium with an equal percentage of copper gives a very dense metal. For instance, a 3-in. flanged valve with  $\frac{1}{2}$ -in. wall (96 per cent Al, 2 per cent Cu, 2 per cent Mg) was tested to 300 lb. per sq.in. hydraulic pressure without leaking. This valve is now in service under 400 lb. per sq.in. pressure of acetic acid. Other tests have shown equally good results with this alloy.

The commercial advantage of an alloy of this sort is illustrated in a comparison of its price with that of brass or bronze. Considering metal costs only, brass will cost about \$0.26 per lb. and the aluminium alloy

about \$0.43 per lb., but the difference in the specific gravity (the aluminium alloy is about  $\frac{1}{3}$  that of brass) makes the price for any individual piece or casting much less. That is, a brass casting weighing 1 lb. would have a metal cost of \$0.26 per lb. whereas the same casting made of the aluminium-alloy would cost  $1\frac{1}{3}$  of \$0.43 or \$0.14  $\frac{1}{3}$ . The advantages here are evident, especially in view of the fact that aluminium takes a better and a more acid and alkali-resisting polish when it contains a small percentage of magnesium.

The deoxidizing properties of magnesium have been known and applied commercially for ten or fifteen years. Magnesium is used to deoxidize nickel and monel-metal castings; in fact, it is quite essential in this industry.

The same property has recently been applied to the making of copper castings and with some very far reaching possibilities. In deoxidizing copper, magnesium is used in proportions of 0.03 per cent to 0.08 per cent, that is, 1 lb. of magnesium will deoxidize from 1200 to 3000 lb. of copper. As 80 per cent to 90 per cent of the magnesium introduced is consumed in deoxidizing, practically none of it shows in the analysis of the finished casting. Magnesium also gives a very dense metal, so that it is possible to make copper castings having electrical conductivity equal to, if not greater than, that of rolled electrolytic copper. The development of this use in the electrical industry makes possible the substitution of copper castings for machined copper thus saving machining costs, reducing the copper scrap and decreasing production costs. Other applications may follow this important use for magnesium.

The action of magnesium in brasses and bronzes is similar to that in copper and an equal amount of magnesium will deoxidize these alloys. As a deoxidizing agent in these alloys, magnesium is cheaper than phosphorus or phosphor-copper, and may be used in their place, except where specifications require a final analysis showing phosphorus. Its cheapness, combined with the fact that it gives a dense and stronger casting, will greatly increase its use in this branch of the metal industry.

A remarkable result of introducing less than 0.1 per cent of magnesium in brasses is that the tensile strength of a brass will be increased from 40 to 60 per cent. This is not obtained at the expense of elongation or ductility as the elongation is increased at the same time.

Magnesium, contrary to the usual rule, is a good bearing metal. Some of its alloys have wearing qualities equal if not superior to cast iron. Its hardness is somewhat greater than that of tin and its heat conductivity is exceeded only by silver, gold and copper. When its specific gravity is taken into consideration, its price per unit of volume is now one-half that of tin.

Magnesium is ductile and may be worked at temperatures between 300 and 400 deg. C. It may also be rolled into sheets, drawn into wire and produced in many commercial forms. As these and many other uses are future possibilities rather than present applications they need not be discussed here. Its use as a deoxidizer of other metals and alloys, however, is widespread and is helping in no small way to win the war.

## A Statistical Summary of Tin

A Review of the Development of the Economic Uses of Tin—History of Its Commerce—Production, Consumption and Average Prices—Measures Taken to Reduce Consumption

BY EDITH M. MILLER

Statistician, National Bank of Commerce in New York

AT THE inter-allied conference recently held in London it was decided to allot to the United States about 80,000 tons of pig tin or two-thirds of the world's entire production annually. Thus was our preëminence as a tin consumer recognized. Tin has been known to man from prehistoric time. The introduction of the use of tin as an unalloyed metal took place at a much later date than its first use as a constituent of bronze. When it was first recognized in the pure form is not known, but we do know that its Latin name, stannum, took final form in the fourth century, and that tin was imported from Cornwall into Italy after the Roman invasion. Increase in the production of tin and in its use has taken place gradually through a long period of time. During the eighteenth century the world's supply of tin was mainly drawn from the deposits of England, Saxony and Bohemia. The total amount produced, however, cannot have been very large, for in 1801 but 2,500 tons were produced in England. The nineteenth century witnessed the predominance of the English mines, whose output remained at about 10,000 tons for the most of the last half of the century. During the last decade of the nineteenth century, however, the yield in Cornwall declined very much and since 1900 has been around 5000 tons annually.

In the opening decades of the nineteenth century supplies began to be drawn from the Island of Banca in the Dutch East Indies. Billiton became of note in 1863 with a production of 40 tons. The Straits Settlements became an important producer in 1870 when the total amount mined there was 2337 tons. At the present time the chief producing regions of the world are the Straits Settlements, Bolivia, Dutch East Indies, notably Banca and Billiton, South Africa, Cornwall, China and Australia. The Straits Settlements produces approximately half of the entire output of the world.

### USES OF TIN

The uses to which tin is put in modern industry are very numerous. The largest single demand for tin comes in the manufacture of tin-plate and terne plate. Tin-plate is used for making receptacles of all kinds—kitchenware and containers for a great variety of products, both food and non-food.

The greatest single source of demand for tin-plate is for food containers. In 1914 the amount of tin-plate used for food cans and cups was sixty-five per cent of the total tin-plate manufactured. Estimates for 1917 indicate that at least seventy-five per cent was so used during that year. The process of canning was discovered in France in 1810 by Nicholas Appert of Chalons-on-Marne, and throughout its development has been

intimately associated with the waging of war. This form of food preservation was conceived primarily as a military measure to secure better stores for the army and navy. The canning industry began in France and the British Isles almost simultaneously, and was brought soon after to the United States, where it has attained its highest development. Very little progress was made in the industry prior to 1855 in this country, the principal pack being sea-food. It was during the decade of the Civil War that the superiority of canned foods over those which were dried, salted and pickled became common knowledge. The soldiers in detention camps and hospitals, although they were supplied with very small quantities, realized the excellent values of canned foods and carried the knowledge home.

The necessity for the preservation and shipment of a great variety of food products to the armies in France, both our own and those of our allies, has again caused an expansion of the canning industry and has rendered the tin supply a question of vital interest because of its intimate connection with the prosecution of the war. One-tenth or more of the tin-plate used in the United States for packing food goes into cans for condensed milk and evaporated milk. This ratio has not been increasing to any marked degree because the increase in other branches of food canned has almost kept pace with the increase in tin-plated milk production. For his canned milk alone it is estimated that each soldier will require five pounds of tin-plate per year.

Tin and tin-plate also have other important uses from a military standpoint besides the necessity for food containers. Tin-plate is used for cans for carrying gasoline to the front, for cases for shells etc. A considerable amount of babbitt metal containing tin is used in certain bearings in naval and other military machinery. It was to secure an adequate supply of tin for Government war work that tin stocks were commandeered in this country at various times during the winter.

Terne-plate is prepared with an alloy of tin and lead and is largely used in metal roofing. In addition to the alloy used to make terne-plate there are a number of other important tin alloys; bronze, for instance, is an alloy of tin and copper; babbitt metal, used in the bearings of machinery, is an alloy of copper, antimony and tin; and pewter is composed of various mixtures of tin with other metals.

Tin is used likewise to weight silk and in the manufacture of tin foil, parts of motors and machinery, wire, rubber, and chemicals. Many other industries use tin in small amounts as alloys or otherwise. Although their demand is not large, tin is none the less indispensable to their uninterrupted operation.

The increase in the production and consumption of tin in the last twenty years has been tremendous. In 1897 the total production of the world was 73,499 tons. In 1907 it had increased to 92,290 tons, while in 1917 the world's production was 120,918 tons, an increase of 65 per cent in twenty years.<sup>1</sup>

#### RELATION OF U. S. TO WORLD SUPPLY

Although the United States is the greatest consumer of tin in the world, tin in commercial quantities is not produced within our borders. Alaska produced ninety-one gross tons in 1915 and one hundred twenty-five gross tons in 1916. Beyond this very limited Alaskan output, our tin production is entirely negligible, although there are a few scattering deposits in a number of states. The problem of our tin supply, therefore, is the problem of the world's tin supply and our relation to it as a buyer in the international market.

Straits tin is by far the largest factor in the world's

The great bulk of tin produced in the Peninsula comes from the Federated States. The Straits Settlements, however, occupies the dominant position in tin output, because of the enormous smelting industry which has been built up at Singapore and Penang for the reduction of ore mined in that part of the world. In addition to the tin obtained from the extensive mining operations in the Federated and Non-Federated States, large quantities of tin ore are imported into the Straits Settlements for smelting purposes from the Dutch East Indies, Siam, Australia, and other tin producing countries. The tin actually mined in the Peninsula in 1915 amounted to 50,876 tons and in 1916 to 48,253 tons. Comparison with Table II shows that the exports from the Straits Settlements exceeded the production in the Peninsula by 17,913 tons in 1915 and 16,948 tons in 1916.

A growing interest in rubber production in which there have been very large profits is said to have seri-

TABLE I—WORLD'S TIN SUPPLIES (a)

| Year | (Gross Tons)        |           |         |              |       |                        |                        |                     |         |  |
|------|---------------------|-----------|---------|--------------|-------|------------------------|------------------------|---------------------|---------|--|
|      | Straits Settlements | Australia | Bolivia | South Africa | China | Banca Sales in Holland | Billiton Sales in Java | Cornwall Production | Total   |  |
| 1908 | 60,500              | 5,850     | 17,000  | 1,700        | ..... | 11,500                 | 2,200                  | 5,400               | 104,150 |  |
| 1909 | 58,500              | 5,350     | 18,000  | 3,000        | ..... | 11,600                 | 2,200                  | 5,600               | 104,250 |  |
| 1910 | 54,600              | 4,650     | 17,550  | 3,000        | ..... | 13,500                 | 2,200                  | 5,800               | 103,500 |  |
| 1911 | 55,100              | 4,000     | 22,600  | 2,900        | ..... | 15,000                 | 2,200                  | 5,300               | 109,600 |  |
| 1912 | 59,000              | 3,800     | 21,200  | 3,100        | ..... | 16,000                 | 2,200                  | 5,500               | 114,600 |  |
| 1913 | 62,500              | 3,200     | 24,850  | 3,200        | ..... | 14,800                 | 2,200                  | 5,800               | 119,000 |  |
| 1914 | 63,000              | 1,800     | 18,750  | 5,000        | ..... | 9,300                  | 1,250                  | 6,600               | 107,000 |  |
| 1915 | 66,500              | 2,550     | 23,000  | 3,500        | ..... | 14,350                 | 1,900                  | 5,600               | 121,800 |  |
| 1916 | 61,600              | 2,650     | 19,400  | 6,000        | (c)   | 17,800                 | 2,500                  | 4,500               | 117,250 |  |
| 1917 | (d) 62,366          | (e) 1,483 | 24,058  | 6,650        | (c)   | 15,209                 | (d) 1,304              | 4,100               | 120,918 |  |

(a) From *Metal Statistics*, 1918, p. 253. The figures do not agree with British figures given in Quinn's "Metal Handbook and Statistics," 1917, possibly because of being made up on a slightly different basis.

(b) 15,100 tons to Europe, 4,300 tons to United States.

(c) 1,300 tons to Europe, 1,500 tons to United States.

(d) Partly estimated.

(e) Arrivals in the United States.

market. Next in importance is Bolivian tin, while Banca tin is third. There are also Chinese, English, Australian, and South African tin, but they have always been regarded as of minor importance.

The United Kingdom, through her intimate connection with most of the important producing regions, is in a dominant position as to the tin market of the world. The Straits Settlements, Australia, South Africa and Cornwall, both as to tin production and shipment, are all British controlled. In 1917 the tin from these sources comprised sixty-two per cent of the entire world output.

With the exception of England, the regions from which the world's supplies of tin come are not consumers of tin, and the record of their shipments is the index to their production. Table I, therefore, indicates with approximate accuracy world tin production from 1908 to 1917:

The tin output of the Malay Peninsula, including the Straits Settlements and the Federated Malay States, is so important that it deserves special attention. The combined output of the British possessions and protectorates in this region amounts to over half of the world's production. The output of each of the important producing regions has varied considerably in the last decade, but the total production has increased rather steadily, the increase for the ten years being sixteen per cent.

<sup>1</sup>*Metal Statistics*, 1918, p. 253; also *Mineral Resources of the U. S.*, 1904.

ously curtailed production in certain of the States. Large numbers of coolies have been attracted to rubber estates by higher wages, thus decreasing the available supply of mine labor.

Table II gives the exports of tin from the Straits Settlements, by principal countries of destination, for the years 1915 and 1916, according to the official returns:

TABLE II—TIN EXPORTS FROM STRAITS SETTLEMENTS (a)

| Destination             | Quantity (Gross Tons) |        | Value        |              |
|-------------------------|-----------------------|--------|--------------|--------------|
|                         | 1915                  | 1916   | 1915         | 1916         |
| United Kingdom.....     | 22,724                | 25,074 | \$17,245,070 | \$21,580,909 |
| United States.....      | 32,286                | 28,100 | 24,378,322   | 23,715,938   |
| Philippine Islands..... | 1                     | 304    | 1,095        | 264,754      |
| France.....             | 4,697                 | 4,248  | 3,503,127    | 3,602,767    |
| Italy.....              | 1,938                 | 2,063  | 1,460,031    | 1,739,556    |
| Russia.....             | 4,147                 | 1,713  | 3,150,490    | 1,413,128    |
| Spain.....              | 180                   | 343    | 135,625      | 22,202       |
| China.....              | 130                   | 16     | 97,283       | 13,420       |
| Japan.....              | 949                   | 1,195  | 726,646      | 1,012,111    |
| India.....              | 1,357                 | 1,384  | 1,811,101    | 1,182,265    |
| Other countries.....    | 378                   | 761    | 282,400      | 627,159      |
| Total.....              | 68,787                | 65,201 | \$52,011,190 | \$55,444,209 |

(a) U. S. Commerce Reports, October 8, 1917.

The tin which comes to this country is chiefly in the form of bars, blocks, pigs, or grain and granulated tin.

The country from which tin is imported, according to the return of the United States Bureau of Foreign and Domestic Commerce, is not necessarily the country of origin. Imports from the Netherlands are re-exports from the Dutch East Indies. Similarly, a considerable amount of the tin shipped from the United Kingdom is Straits tin, or the product of other mines which has come through British ports. In 1917, sixty per cent of our tin was mined in the Straits Settlements, sev-



enteen per cent in Banca and Billiton, and eleven per cent in England.<sup>2</sup>

Table III shows the imports of tin into the United States by countries, from 1908 to 1918, inclusive. In this table our importation of tin ore is not included:

TABLE III—IMPORTS INTO THE UNITED STATES, 1908 TO 1917 (a)

| Year | Germany | United Kingdom lands | Netherlands | (Gross Tons) Dutch East Indies | Straits Settlements | Hong-kong | Australia | All Others | Total  |
|------|---------|----------------------|-------------|--------------------------------|---------------------|-----------|-----------|------------|--------|
| 1908 | 659     | 24,650               | 244         | ..                             | 8,600               | 14        | 76        | 264        | 34,507 |
| 1909 | 975     | 24,142               | 335         | ..                             | 14,816              | 151       | 170       | 91         | 40,680 |
| 1910 | 1,989   | 25,272               | 372         | ..                             | 16,819              | 484       | 143       | 70         | 45,149 |
| 1911 | 2,341   | 26,967               | 1,857       | ..                             | 13,472              | 820       | 507       | 214        | 46,178 |
| 1912 | 1,771   | 29,513               | 1,808       | ..                             | 14,855              | 852       | 210       | 636        | 49,645 |
| 1913 | 1,378   | 23,366               | 1,576       | ..                             | 22,698              | 1,396     | 179       | 620        | 51,213 |
| 1914 | 1,834   | 23,674               | 369         | 25                             | 17,481              | 1,013     | 130       | 196        | 44,722 |
| 1915 | 224     | 20,495               | 130         | 1,620                          | 19,265              | 329       | 117       | 170        | 42,350 |
| 1916 | ..      | 18,650               | ..          | 6,351                          | 36,432              | 1,830     | 150       | 886        | 64,279 |
| 1917 | ..      | 18,726               | ..          | 11,357                         | 25,098              | 2,264     | 1,334     | 2,439      | 61,418 |
| 1918 | ..      | 13,211               | (b)         | 10,355                         | 25,084              | 6,037     | 3,255     | 2,924      | 60,946 |

(a) From U. S. Bureau of Foreign & Domestic Commerce, Commerce and Navigation of the U. S., 1911-1916, and Monthly Summaries of Foreign Commerce of the U. S., June, 1918.

(b) No method of determining whether included in "All Others"

It will be observed that our imports of tin increased steadily from 1908 to 1913. In 1914 and 1915 there



TIN MINE, BOLIVIA

was a decided falling off. In 1916, however, our imports not only recovered, but exceeded all previous records. In 1917 and in 1918 our imports declined from the high level of 1916 but were substantially greater than in 1915 or any preceding years. The effect of the war on shipping routes, which will be discussed later, is clearly shown in the above table. Prior to 1914 we received no tin directly from the Dutch East Indies, but received it by way of the Netherlands. Since the war the Dutch East Indies has been shipping to us directly.

Interesting to note is the fact that while in 1914 our importations of tin from the United Kingdom and from the Straits Settlements formed 90 per cent of the total, in 1918 they amounted to only 63 per cent of the total. The loss was in a large degree offset by heavier shipments from Hongkong, Australia and the countries not separately shown.

It should be noted that total imports of metallic tin for 1918 including the tin content of the ore imported, were said to set a new high record and to total 69,731 tons as compared with 67,529 tons in 1916. Our importation of tin ore previous to the fiscal year 1916 was so small that it was not reported separately by the Bureau of Foreign and Domestic Commerce. Owing to the absence of smelters in the United States, until very recently we could not bring South America

tin direct from the Bolivian mines. Instead, ore had to be shipped to Europe or the East for smelting before any of it found its way into the markets of this country.

In the fiscal year 1916, 5415 tons of tin ore were received from South America, and two tons from Panama. During the fiscal year 1917 we imported 5120 tons, and in 1918, 14,816 tons. According to figures recently compiled by the Bureau of Foreign and Domestic Commerce, our 1918 tin ore imports were equivalent to 8,785 tons of metallic tin and thus "approximately 13 per cent of our 1918 imports came to us in the form of ores, mostly from Bolivia."

#### WORLD CONSUMPTION

It is not possible to get exact data on tin consumption, but the amount of tin stocks in the chief markets of the world may be compared from year to year. Such comparison should serve at least to show whether production is increasing faster than the demand for tin, or whether tin stocks are being depleted through a rate of consumption faster than the rate of production.

Table IV shows stocks of tin in London, Holland and the United States (exclusive of Pacific ports) at the close of each month, from 1913 to 1917, inclusive. The stocks fluctuate widely, but it can be seen that there is no very marked tendency towards an increase or a decrease. The consumption is evidently about keeping pace with the production, and *vice versa*.

TABLE IV—WORLD'S STOCKS OF TIN (a)

| Month     | 1913  | (Gross Tons) 1914 | 1915  | (b) 1916 | (b) 1917 |
|-----------|-------|-------------------|-------|----------|----------|
| January   | 4,648 | 9,609             | 5,454 | 5,566    | 6,368    |
| February  | 3,779 | 8,067             | 4,039 | 3,906    | 6,949    |
| March     | 4,780 | 10,189            | 6,345 | 5,293    | 7,036    |
| April     | 4,029 | 10,056            | 8,540 | 6,626    | 5,745    |
| May       | 5,962 | 9,927             | 4,877 | 6,849    | 8,165    |
| June      | 3,564 | 8,776             | 4,761 | 7,124    | 5,270    |
| July      | 5,332 | 8,648             | 4,014 | 8,887    | 5,854    |
| August    | 3,472 | 8,257             | 6,346 | 8,892    | 6,860    |
| September | 6,218 | 8,728             | 8,223 | 8,799    | 5,638    |
| October   | 4,999 | 5,079             | 7,164 | 7,472    | 7,472    |
| November  | 6,741 | 4,558             | 4,848 | 7,560    | 6,483    |
| December  | 6,384 | 4,926             | 5,274 | 7,801    | 4,977    |
| Average   | 4,992 | 8,114             | 5,675 | 7,034    | 6,401    |

(a) From Metal Statistics, 1918, p. 265.

(b) Includes stocks at U. S. Pacific ports.

#### TIN CONSUMPTION IN THE UNITED STATES

A decided increase in our tin consumption took place in 1916 and 1917.<sup>4</sup> This increase is not only absolute, but the percentage of the world's consumption which was consumed in this country increased from forty-two per cent in 1915 to fifty per cent in 1917. Whether this is a temporary condition which will readjust itself after the war is impossible to predict, but the war has evidently caused a lessening of the manufacture of tin products in Europe and a corresponding stimulation of the industry in this country.

At the present time, a much larger share is consumed by this industry. Exact data are not available, but it is likely that the quantity so used approximates two-fifths of the total amount of tin used in manufactures in this country. Before the war, during 1912 and 1913, about one-third of the total amount of tin consumed was used in the production of tin plate. Our production of tin-plate, terne plate, and taggers' tin, has increased from 1,153,097,000 pounds in 1908 to an estimated 3,360,000,000 pounds in the calendar

<sup>1</sup>U. S. Commerce Reports, July 31, 1918.

<sup>2</sup>Metal Statistics, 1918, page 259.

<sup>3</sup>Metal Statistics, 1918, page 269.

year, 1917. Our net imports have declined so as to be almost negligible, while exports for 1917 are over 15 times what they were in 1908. There was no great increase in tin-plate retained for consumption up to 1917 but during the year just past, our consumption of tin-plate increased very decidedly, the consumption for the year 1918 exceeding that for the year 1917 by more than twenty-five per cent.

Table V shows the marked increase in our tin-plate industry:

TABLE V—TIN PLATES, TERNE PLATES, AND TAGGERS' TIN (a)

| Year Ending<br>June 30 | Production<br>(In Thousand Pounds)<br>(b) | Exports | Net<br>Imports | Total Retained<br>for Consumption |
|------------------------|-------------------------------------------|---------|----------------|-----------------------------------|
| 1908                   | 1,153,097                                 | 33,623  | 140,681        | 1,260,155                         |
| 1909                   | 1,203,075                                 | 11,411  | 117,301        | 1,308,965                         |
| 1910                   | 1,370,788                                 | 26,168  | 134,369        | 1,498,889                         |
| 1911                   | 1,619,005                                 | 70,199  | 95,320         | 1,644,126                         |
| 1912                   | 1,756,070                                 | 181,899 | 6,230          | 1,580,401                         |
| 1913                   | 2,157,055                                 | 164,362 | 28,331         | 2,021,024                         |
| 1914                   | 1,845,130                                 | 105,900 | 48,871         | 1,788,101                         |
| 1915                   | 2,085,980                                 | 179,221 | 9,992          | 1,916,751                         |
| 1916                   | 2,365,296                                 | 516,257 | 1,789          | 1,850,828                         |
| 1917                   | 2,766,400                                 | 521,861 | 1,358          | 2,255,897                         |
| 1918                   | (c) 3,360,000                             | 563,068 | 71             | 2,797,003                         |

(a) From a Statistical Abstract of the U. S. and June, 1917, Summary of Foreign Commerce of the U. S.

(b) Production is for the calendar year preceding the fiscal year.

(c) Estimated, from *Iron Age*, Jan. 3, 1918, page 65

Our net imports, that is to say, the difference between our total imports of tin plates, terne plates and taggers' tin, and the amount of tin foreign plates and taggers' tin were not very large as compared to our production in any of the years shown in the table, but they have fallen off very markedly since the outbreak of the war.

The expansion of our exports is primarily due to the fact that those European countries normally producing tin-plate for export have been compelled by the war to apply their productive efforts in other directions.

The manner in which the United States has taken advantage of markets thus available is shown by Table VI:

TABLE VI—U. S. EXPORTS OF TIN PLATES, TERNE PLATES, AND TAGGERS' TIN, 1908 TO 1917 (a)

| TABLE 4. COUNTRY OF ORIGIN OF THE VESSELS, BY VESSEL TYPE, AND TONNAGE TON, 1908 TO 1917 IN |        |                            |                   |        |               |        |                  |              |         |  |
|---------------------------------------------------------------------------------------------|--------|----------------------------|-------------------|--------|---------------|--------|------------------|--------------|---------|--|
|                                                                                             |        | (Gross Tons)               |                   |        |               |        |                  |              |         |  |
| Year                                                                                        | Canada | Argentina<br>and<br>Brazil | United<br>Kingdom | China  | Hong-<br>kong | Japan  | British<br>India | All<br>Other | Total   |  |
| 1908                                                                                        | 13,888 | 127                        | .....             | 81     | .....         | 343    | .....            | 571          | 15,010  |  |
| 1909                                                                                        | 3,441  | 17                         | .....             | .....  | 328           | 188    | .....            | 1,112        | 5,094   |  |
| 1910                                                                                        | 10,618 | 36                         | 1                 | 57     | 24            | 1      | .....            | 945          | 11,682  |  |
| 1911                                                                                        | 20,544 | 999                        | .....             | 3,212  | 1,099         | 708    | 1,888            | 2,889        | 31,339  |  |
| 1912                                                                                        | 37,801 | 5,984                      | 298               | 9,812  | 4,678         | 4,239  | 8,223            | 9,870        | 81,205  |  |
| 1913                                                                                        | 52,044 | 5,865                      | .....             | 2,234  | 1,189         | 1,239  | 456              | 10,349       | 73,376  |  |
| 1914                                                                                        | 32,663 | 2,082                      | .....             | 4,012  | 1,505         | 192    | 9                | 6,813        | 47,276  |  |
| 1915                                                                                        | 34,196 | 10,343                     | .....             | 10,223 | 2,904         | 2,074  | 3,012            | 17,258       | 80,010  |  |
| 1916                                                                                        | 52,395 | 29,673                     | 29,784            | 15,808 | 14,259        | 24,638 | 20,334           | 43,581       | 230,472 |  |
| 1917                                                                                        | 59,654 | 36,854                     | 8,696             | 13,642 | 9,897         | 20,728 | 17,786           | 65,717       | 232,974 |  |
| 1918                                                                                        | 55,853 | 47,395                     | 1,332             | 6,385  | 10,349        | 36,021 | 9,960            | 84,076       | 251,371 |  |

(a) From U. S. Bureau of Foreign & Domestic Commerce, Commerce and Navigation of the United States, 1911, 1916, and Monthly Summary of Foreign Commerce of the U. S., June 1918.

Considerable irregularity is to be noted in our tin-plate exports up to and including the fiscal year 1915. Exports for 1916, however, amounted to three times the total for 1915. Canada is and has always been our single largest customer for tin-plate, but the increase in our exports to Canada was not so marked between the outbreak of the war in the fiscal year 1915 and in 1916 as was the increase in exports to the United Kingdom, to Japan, and to British India.

Export license requirements discussed elsewhere went into effect on Oct. 24, 1917. In spite of these restrictions our exports for the fiscal year ending June 30, 1918 increased eight per cent to 251,371 tons over the exports in the preceding fiscal year. We exported

less tin and terne plates and taggers' tin to Canada, the United Kingdom, China and British India, but more to Argentina and Brazil, Hongkong, Japan, and the countries grouped in the classification "All others."

#### INTERNATIONAL RELATIONS

Under an agreement recently reached by representatives of the United States, Great Britain, France, and Italy at conferences held in London, each of these countries will get its needed supply of pig tin. The action amounts to an international monopoly of a beneficent nature.

The plan of distribution worked out allows the United States about 80,000 tons of pig tin or two-thirds of the world's entire production annually.

With the War Industries Board supervising the allowance to this country, all imports of pig tin, in ores and concentrates will be assigned to the American Iron and Steel Institute which will receive pay for and distribute the metal to the industry through the United States Steel Products Co.

The price will be regulated by the War Industries Board and will be uniform to consumers of 10 tons of pig tin or over. There will be another uniform price for users of less than 10 tons. These prices will be maintained at a level which will encourage production in the tin mining countries—Great Britain and the Straits Settlements chiefly—and stop profiteering. Prices, rules, and regulations will be announced later. It is probable that users and dealers may be licensed.

The War Industries Board believes there will be insured by these arrangements a steady supply of material at a stable and reasonable price. Since the negotiations for the pooling arrangement began in London six weeks ago the price of pig tin has fallen steadily. The quo-

tation of Sept. 6 last showed a net decrease of 14 cents per pound as compared with the price on July 15, 1918.<sup>a</sup>

Within the last year complications with Holland have threatened to tie up tin shipment from Banca and Billiton. On April 22, 1918, Holland imposed an export license on tin and tin ore leaving the Dutch East Indies, but it is understood that this is not at present to interfere with traffic with the United States.

#### GOVERNMENT CONTROL

The export of tin-plate from the United States was first restricted by regulation of the War Trade Board

<sup>a</sup>Official Bulletin, September 11, 1918.

announced on October 24, and amplified on November 12, 1917. According to these rulings, all exports of tin plate and articles containing tin were placed under license, whose issuance was carefully regulated by the proof in each case as to the use to which the goods were to be put. Preference was given for the exportation of tin-plate for use for any other purpose than as food containers, or of articles other than tin-plate, containing tin, except on satisfactory evidence that the goods would be used in such a way as to contribute to the military needs of the nations at war with Germany and her allies. Licenses might be granted for the exportation of articles other than tin-plate containing tin, if the goods would be used to contribute to vital needs other than military of the nations at war with Germany and her allies. No license was to be granted except to manufacturers, or others who could present satisfactory evidence that they had purchased the plate from a manufacturer on firm order from a purchaser abroad.

On March 6, 1918, further restriction on the exportation of tin and terne-plate was announced by the War Trade Board, with the object of directing the supply



VICTORIA CONCENTRATING WORKS, AUS TIN MINE

for the benefit of the allies. The rules announced supplement those already in force and are as follows:

Licenses may be granted to manufacturers of tin-plate and terne-plate or to persons other than a manufacturer, provided the purchase of the plate has been made directly from a manufacturer prior to November 12, 1917, and also provided such purchase has been made to fulfill a contract or firm order from a purchaser abroad placed with a firm in the United States, a copy of which must be annexed to the application. Export licenses for tin-plate or terne-plate may be granted only for shipment to Canada, South and Central American countries, including Mexico and the West Indies, China and Japan, and only when the plate is to be used either—

1. To manufacture containers for edibles for human consumption by the people of the nations at war with Germany and her Allies, or
2. To manufacture oil cans, provided the plate has been ordered from the mill on or before August 27, 1917. In this case there shall be no distinction between purchases from manufacturers and purchases from others, or
3. When the plate is to be shipped to any of the above mentioned countries except Canada, it is to be used for purposes which shall contribute directly to the successful prosecution of the war, or
4. When the plate is destined for Canada it is to be

used for purposes for which tin-plate or terne-plate is now permitted to be used in the United States.<sup>1</sup>

Despite these regulations, export figures, as already noted, indicate no noteworthy reduction in our exports of tin-plate. Exports to the Allies constitute an essential part of the war programme. For example, the French Government has proposed an exchange of services for 1918 whereby France will undertake to pack enough canned goods for herself and for the American forces abroad, provided the United States will furnish the tin-plate. The labor will largely be performed by women and it is estimated that the saving in ocean tonnage will be considerable. Exports to neutrals, and to countries not actively assisting the Entente Allies in the prosecution of the war totalling perhaps 50,000 tons for the fiscal year just closing, are difficult of explanation in the face of the apparent tin shortage.

In the absence of Government price control, tin prices have naturally reflected the scarcity which has existed for so many months, both in this country and in England. Prices have gone far above all previous records. In this country the virtual absence of spot tin has made price a more or less theoretical question, but it is safe to say that tin prices have doubled in the last two years.

Table VII shows the trend of tin prices on the London market for the years 1911 to 1917, inclusive:

TABLE VII—MONTHLY AVERAGE PRICES OF TIN IN LONDON (a)

| Month        | 1911  | 1912  | 1913  | 1914      | 1915  | 1916  | 1917  |
|--------------|-------|-------|-------|-----------|-------|-------|-------|
| January....  | 40 71 | 41 65 | 49 64 | 37 38     | 34 04 | 38 20 | 40 48 |
| February.... | 41 20 | 42 42 | 47 86 | 39 45     | 38 47 | 39 36 | 43 23 |
| March.....   | 39 63 | 41 87 | 46 40 | 37 80     | 39 22 | 42 08 | 45 99 |
| April.....   | 41 94 | 43 54 | 48 82 | 35 67     | 36 17 | 43 34 | 47 84 |
| May.....     | 42 97 | 43 52 | 48 82 | 32 80     | 35 40 | 42 73 | 53 26 |
| June.....    | 45 06 | 44 74 | 44 44 | 30 16     | 36 47 | 39 03 | 52 66 |
| July.....    | 41 95 | 43 97 | 39 94 | 30 96     | 36 35 | 36 60 | 52 65 |
| August.....  | 41 39 | 45 22 | 41 05 | 30 21 (a) | 32 94 | 36 93 | 53 00 |
| September..  | 39 29 | 48 66 | 42 01 | 29 47 (b) | 33 22 | 37 24 | 53 00 |
| October..... | 40 66 | 49 65 | 40 19 | 28 01 (b) | 32 98 | 38 98 | 53 76 |
| November..   | 42 36 | 49 30 | 39 32 | 30 13 (c) | 36 48 | 40 62 | 59 78 |
| December..   | 44 18 | 49 29 | 37 35 | 31 98     | 36 32 | 39 86 | 64 87 |
| Average..    | 41 78 | 45 33 | 43 82 | 32 84 (c) | 35 67 | 39 58 | 51 64 |

(a) From *Metal Statistics*, 1918, p. 279.

(b) Based on private transactions.

(c) Based partly on private transactions.

These prices vary rather markedly from the New York prices as shown below. The variations were minor, however, before the shipping crisis became so acute, the difference becoming greater as the difficulties of shipping increased.

#### MEASURES TO REDUCE CONSUMPTION OF TIN

Until war conditions forced the subject upon us, no attention had been paid in the United States to the conservation of tin. The danger of a tin shortage in the

TABLE VIII—PIG TIN PRICES IN NEW YORK (a)

| Months       | 1911  | 1912  | 1913  | 1914  | 1915  | 1916  | 1917  |
|--------------|-------|-------|-------|-------|-------|-------|-------|
| January....  | 41 39 | 43 24 | 50 45 | 37 74 | 34 30 | 41 88 | 44 19 |
| February.... | 42 83 | 43 46 | 48 73 | 39 93 | 37 32 | 42 63 | 51 37 |
| March.....   | 40 76 | 42 86 | 46 88 | 38 08 | 40 93 | 50 42 | 54 36 |
| April.....   | 42 20 | 44 02 | 49 12 | 36 10 | 47 98 | 51 75 | 55 91 |
| May.....     | 43 10 | 46 12 | 49 14 | 33 30 | 38 78 | 49 15 | 63 29 |
| June.....    | 46 16 | 47 77 | 44 93 | 30 65 | 40 37 | 42 18 | 62 09 |
| July.....    | 42 96 | 44 75 | 40 39 | 31 75 | 37 50 | 38 46 | 62 60 |
| August.....  | 43 45 | 45 87 | 41 72 | 50 59 | 34 39 | 38 54 | 62 68 |
| September..  | 39 98 | 49 18 | 42 47 | 32 79 | 33 13 | 38 70 | 61 68 |
| October..... | 43 21 | 50 11 | 40 50 | 30 39 | 33 08 | 41 16 | 61 85 |
| November..   | 43 13 | 49 90 | 39 81 | 33 50 | 39 37 | 44 17 | 74 42 |
| December..   | 44 97 | 49 90 | 37 64 | 33 60 | 35 72 | 42 66 | 85 35 |
| Average..    | 42 68 | 46 43 | 44 32 | 35 70 | 38 66 | 43 48 | 61 65 |

(a) From *Metal Statistics*, 1918, p. 277.

(b) Market strictly nominal December 12 to 31; 86.00c. used for those dates as arbitrary basis in computing the month's average.

<sup>1</sup>New and more complete regulations were issued by the War Trade Board (W.T.B. 203) too late to be included in this article. The changes from the above consist mainly in classifying the exports and giving specific instructions as to procedure.



food packing industry was recognized in the Spring of 1917 and, by voluntary agreement, packers of non-perishable foods stopped running during June and July in order to insure an adequate supply of tin cans for the perishable crop then coming on. Since that time conservation in various directions has been urged and, to a degree, has taken place.

The conservation of tin plate is of prime importance. According to the War Trade Board, "That there may be a sufficient supply of tin in the United States to meet the war needs and to supply essential civilian uses, vigorous plans for conservation of the metal are being made effective through coöperative efforts by the War Industries Board and by the Food and Fuel Administrations in the enforced substitution of other than tin containers, wherever that is possible. Tin container manufacturers have agreed with the War Industries Board in plans that will curtail their use of tin plate 13 per cent which means a saving in the next three months of about 150,000 tons of tin plate.

The Food Administration is working out a tin conservation plan with various industries, including lard and lard compound packers, wholesale grocers, cracker manufacturers, tea and coffee packers, cocoa and chocolate manufacturers, and baking-powder manufacturers. All have been urged to substitute fiber, paper, or other containers where possible.

The Fuel Administration has taken up the subject with the oil dealers and the War Industries Board is working along similar lines with the tobacco manufacturers and all industries in which tin is used in turning out the finished product.<sup>6</sup>

The substitution of other materials for tin containers has gone much further abroad than it has in the United States, and the possibilities in this direction are great. During August, 1917, a cardboard container was developed in Great Britain for use in packing army jam. Since that time its manufacture has been so developed and extended that there is now an output of 5,000,000 cardboard containers per week. The bulk of these are two-pound size, but a proportion are of one-pound and five-pound sizes and all three are used as substitutes for tin packages. Since last September, in Great Britain, dried foodstuffs and semi-liquid foods have not been "permitted to be packed in tin-plate, nor has fruit. The use of terne-plate for lining packages for the export of textile and other goods has also been prohibited, and where use of tin-plate could not be wholly stopped, economies were attempted by insisting upon the use of larger containers for packing meat and canning milk. The size of oil cans was doubled, and in India tin-plated iron drums were brought into use for petroleum products.

"At the present time tin containers are practically used only for meat and processed foodstuffs. Most of the paper or cardboard containers employed have been largely of the kind known as composite containers, i.e., having tops and bottoms of tin, but it is expected to soon perfect the manufacture of these containers so as to be able to make them all paper products.

"Efforts have been made to introduce substitutes in the army. Cardboard, wood and fiber are now substituted for tin-plate in the manufacture of such things

as card-index boxes and workmen's checks, while earthenware bowls are used instead of the old pudding bowls. Salt, sugar and tea, which formerly were packed in soldiers' rations tins, are now packed in paper bags. Recent regulations of the Ministry of Munitions have put the civilian trade upon a very strict ration, so that there will only be a bare minimum supply of essential articles, such as domestic utensils, stoves, meters and lamps."<sup>7</sup>

While this saving in tin-plate in Great Britain has been primarily for the purpose of conserving steel rather than tin, the result has been to save a large amount of tin.

The Australian Government has forbidden the use of tin-plate for the making of many articles, chief of



SMELTING WORKS AT MIRAFLORES, UNCLIA

which are the containers for boiled sweets, for packing butter in quantities less than two pounds, except for war purposes and for dispatch to soldiers abroad, for the making of second lids for containers of butter and cheese and for use in the manufacture of stoves, phonograph horns and kerosene pumps. That Government has also forbidden the replenishing of stocks of articles made of tin-plate more than is necessary for three months' use, and has forbidden the importation of a number of articles made of tin plate and of many other articles when packed in tin plate.

Reduction of the amount of tin used for purposes other than the manufacture of tin-plate has not been overlooked.

The quantity of tin absorbed in the manufacture of silks is so large that the Government is taking cognizance of the fact. The tin used for this purpose is largely recovered metal, converted into tin tetrachloride and sold to silk dyers for weighting and finishing the fabric. The aggregate amount of tin per year used in the United States for the weighting of silk is not known, but estimates of as much as five thousand tons have been made. The use of tin for weighting is detrimental to the wearing qualities of the silk, and is the chief cause of cracking. It is the purpose of the Government to reduce the amount of tin used in the silk industry to a minimum.

The substitution of lead-base babbitt metal for tin-base babbitt metal, and the reduction of the tin content

<sup>6</sup>Official Bulletin, September 11, 1918.

<sup>7</sup>Journal of Commerce, N. Y., July 15, 1918.

of the tin-base babbitt metal is being urged, as well as economical use of babbitt metal. The Bureau of Standards has completed an investigation of bearing metal and has suggested elimination of all but four grades. It is stated that a saving of about 25 per cent in amount of tin will be affected. Large savings have already been made by automobile and other machine manufacturers by substituting for all metal bearings, case bearings with thin lining shell  $\frac{1}{16}$  to  $\frac{3}{16}$  of an inch high grade babbitt. Straits tin is often specified on the assumption that it is the purest tin. Banca is even purer than Straits or Australian, and electrolytic tin is as pure.

Reduction of the percentage of tin in alloy castings to the lowest possible figure is being advocated, and the substitution wherever possible of a mixture of lead and tin solder for pure tin solder. The Bureau of Standards is making investigation of solder along the same lines as its investigation of babbitt metal. It is stated that "the can companies have reduced the percentage of tin in their solder to forty, thus saving eight to ten per cent without injury to the industry."

"A plan was suggested and is now being perfected for the recovery of a large part of the tin used in foil and tubes. Through a campaign of advertising through notices on the packages and other methods, consumers of articles packed in foil or tubes will be induced to save those articles and turn them in at the nearest Red Cross center as donations. Smelters and other users of tin will then purchase at market rates the lots thus collected by the Red Cross. It is estimated that this will recover some 3000 to 5000 tons of tin per annum and bring the Red Cross an added income of from \$4,000,000 to \$5,000,000."

The possibility of the utilization of empty cans and of the tin in them is also being considered. Oil cans sent from this country to the Orient have been used there for some time in making an inconceivable number of articles—lamps, cook stoves, pots, pans, sprinklers, toys, bottle caps, dust pans etc. The possibility of a notable saving in this country by a similar utilization is now being considered. The Department of Commerce has urged upon State Councils of Defense, Chambers of Commerce and other trade organizations the consideration of the collection of old tin cans before they have rusted, in order to sell them to tinning companies. It is hoped that a considerable amount of tin can thus be recovered. The Food Administration has also advocated the straightening and retinning of dairy cans as a means of saving the tin-plate. Such cans can be renewed at from one-fourth to one-third the cost of new ones.

#### SHIPPING ROUTES FOR TIN

Prior to the war, London was the center of the tin trade of the world. The ruling prices on the London market governed the value of all other grades of tin. Great Britain controls not only Singapore and Penang, from which Straits tin comes, but the Chinese product, which is shipped from Hong Kong. Her control was complete at these ports, not only because of political dominance, but because nearly all the vessels in the tin trade were of British register.

Great Britain made it a definite policy to confine the tin trade as far as possible to London, and for this

reason all consignments destined from Singapore or Penang for America had to come via London, and thence across the Atlantic, though the direct route would have been via the Pacific to San Francisco. Bolivian tin is partly smelted in that country, but prior to the erection of tin reduction works here, much of it was sent to English smelters, and thence to the United States.

The increasing facilities for smelting the tin here will effect an important economy in this shipping. It is reported, moreover, that the Tin Committee of the Council of National Defense has arranged for the direct shipment of tin from the Straits Settlements to the Pacific coast.

Tin, even after it arrived in this country, was customarily subjected to unnecessary shipments. Consignments arriving at the Pacific coast would be bonded to New York, cleared at the Custom House there, and often shipped half way back across the continent to consuming points in the Middle West. The practice was not only expensive, but it led to considerable congestion at the terminal points in New York and to traffic delays in the journey. To reduce such difficulties to a minimum, the Sub-Committee on Pig Tin of the American Iron and Steel Institute has recommended to the tin trade that consignments be passed through the Custom House at the Pacific ports or, if this be impracticable, that they be shipped in bond to Chicago, Pittsburgh, or other convenient points of distribution.

Only once before the beginning of the war had our total imports of tin exceeded 50,000 tons. This was for the fiscal year ending June 30, 1913, when we received 51,213 gross tons. Our average imports for the five fiscal years preceding the outbreak of the war were less than 50,000 tons.

Our total imports of metallic tin for the fiscal year just ended amounted to 69,731 tons, the highest figure in our history. The inter-aliied pooling agreement in allowing us 80,000 tons annually seems to have provided amply for our needs. Of course, the fact that this country has been "allowed" 80,000 tons does not necessarily mean that we will import that much tin. Nevertheless it is an indication that a more plentiful supply may be expected. Normal conditions cannot be hoped for until the close of the war, but reasonable conservation and skillful distribution may be expected to meet the present situation so successfully as to minimize the effects of the disturbing factors which are now affecting the supply of and demand for tin.

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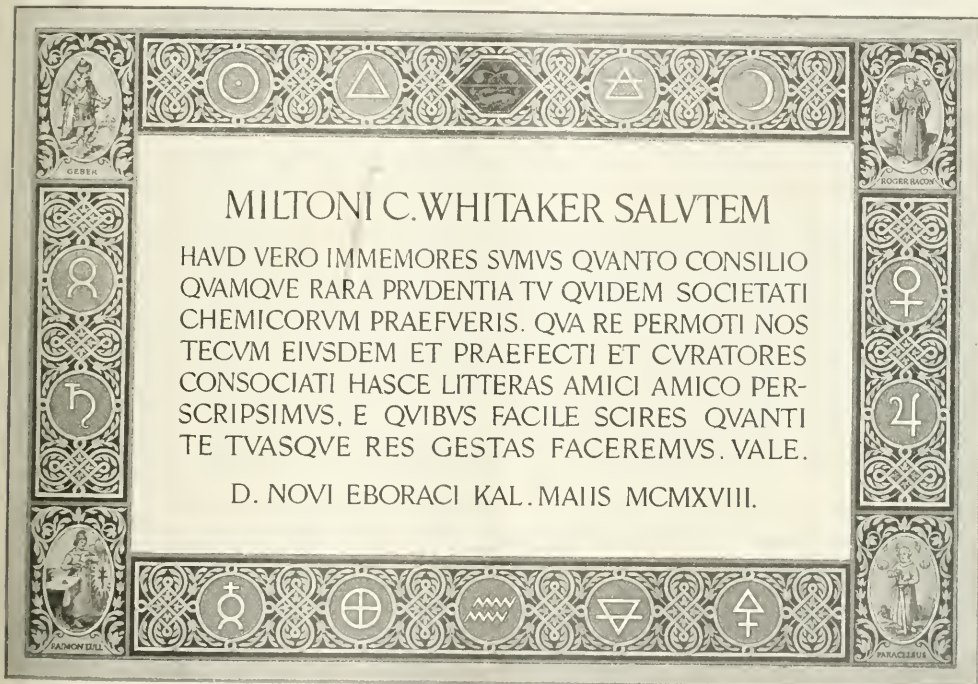
**Bolivian Tin Profits.**—The gross profits of the Llalagua Tin Company, of Bolivia, for 1917 was £1,712,170, against £466,123 in 1916, the dividends distributed absorbed £637,500, while £850,000 was allocated to future dividends. The capital of the company is £425,000, the interest and dividend reserve total £850,000, and other reserves £466,000. The production of concentrates increased from 7460 long tons in 1916 to 11,250 tons last year. The costs of production, etc., were less in 1917 than in 1916, being last year about £36 a ton in 1916. The largest increase was shown by the Llalagua Company, which ranks second as a producing company, being surpassed only by the Patino Company, whose last year's output was 13,300 tons of concentrates, against 10,000 tons in 1916.

## Testimonial to Dr. M. C. Whitaker

WHEN Dr. Milton C. Whitaker retired from the presidency of the Chemists' Club his fellow officers and trustees gave him a silver service in appreciation of his remarkably able administration of the club's affairs. Inasmuch as there was a surplus left after the purchase of the silver, Messrs. Ellwood Hendrick, the succeeding president, Thomas R. Duggan, chairman of the house committee and Dr. Bernhard C. Hesse, conceived the idea that it would be well to add something more personal with the remainder. With the consent of the donors they engaged Mr. Edward B. Edwards

emblem of the Chemists' Club, a benzene ring enclosing a salamander and a flame. The alchemistic symbols in the border beginning at the upper left hand corner and reading around to the right, are as follows: Gold, Fire (Chemists' Club Emblem), Air, Silver, Copper, Tin, Sulphur, Water, Vitriol, Mercury, Lead and Iron. The scheme of decoration is a very happy one and lends itself to the embellishment of halls and buildings devoted to chemistry.

Traditions are beginning to appear at the Chemists' Club. There is a little copper container for coffee which has engraved upon it "The President's Pot," presented a couple of years ago by Mr. Lane of the



to design the memorial of which we give an illustration herewith.

It is framed so that both sides may be seen, the reverse containing the record in English and the names of the donors. The beautiful Latin text is from the pen of Professor McCrea of Columbia University. The English text, which is freely translated, reads as follows:

We, your fellow officers and trustees of the Chemists' Club during the term of your presidency, recognizing your great service in directing its affairs with signal ability and rare foresight, present this minute of our sincere appreciation.

New York, May 1st, 1918.

The memorial is of peculiar interest in that alchemistic symbols are employed in the decoration. In the four corners are vignette portraits of Geber, Roger Bacon, Raymond Lully and Paracelsus copied from an old French work. In the centre of the top border is the

U. S. Appraisers' laboratory, to distinguish the incumbent of the presidential office. Dr. Whitaker refused to turn it over on his retirement without, as he declared, the proper ceremony, and he lately invited the trustees to dine with him at the club before their meeting, to witness him endow it upon his successor for the term of his incumbency.

On receiving his official decoration President Hendrick responded as follows:

This copper Presidential Pot  
Is singular in that it's got  
The function of entailment meant  
For each succeeding President.

Now let's engrave upon it well  
The name of Whitaker to tell  
That it was he who was the first  
To quench his presidential thirst  
From it, when as he broke his fast,  
And also, when the day was past,  
To fill from it his little cup  
To live his digestion up.



Then underneath we lesser men  
May follow him as now and then  
We serve each one his little day  
And, having done so, fade away.

This pot, from which I hope to drink  
My fav'rite coffee, black as ink,  
Is mine in trust but for the span  
That I'm entitled to the can.  
It is not part of my estate.  
And yet I certainly should hate  
To have it used by any slob  
So long as I hold on my job.

This is not spoken as a threat  
Because I've hardly got it yet.  
I merely mention it because  
It is not written in the laws  
And I don't want to strew my path  
With tokens of unholy wrath.

And now I offer you this toast  
For those who really need it most:  
May every one who stays his thirst  
From this pot, emulate the first  
To use it. May he stir  
The Club's dry bones like Whitaker,  
Employing wisdom, judgment and  
The requisite amount of sand,  
Without once ever letting slip  
His standard of good fellowship.

## From A to Z With the Exhibitors

**PROVOST ENGINEERING COMPANY.** Filter presses. Particular developments since the United States entered the war are special filter presses for acids. In charge of exhibit: J. A. NAUGLE, C. A. BEACH.

**QUIGLEY FURNACE SPECIALTIES COMPANY, INC.** Demonstration of the use of hyseltite furnace cement, in a small high-temperature electric furnace. A new insulating brick will also be thus demonstrated and samples of Kieselguhr will be shown. In charge of exhibit: W. S. QUIGLEY, C. P. GANTZMAN, F. J. SPILLANE, J. H. MCPADDEN.

**RARITAN COPPER WORKS.** Products showing the various stages of smelting and refining copper from the ore to commercial bars, together with by-products of the electrolytic refining of copper bullion, such as nickel sulphate, copper sulphate, selenium, tellurium, silver, gold, palladium and platinum. Anaconda electrolytic zinc, common copper, corroding lead and an antimonial lead will also be shown. The production of electrolytic pure zinc has been accomplished since the war began, and has had an important bearing on high-grade munitions. In charge of exhibit: S. SKOWRONSKI.

**RAYMOND BROTHERS IMPACT PULVERIZER COMPANY.** A full line of pulverizing machinery equipped with air separation. Three of the models are one-quarter size of the actual mill, but the fourth will be of the actual size such as is used in the chemical, dry color and dyestuffs industries. All will be in operation in such a way as to show the actual workings of the mill for any particular purpose. In charge of exhibit: R. A. LACHMANN.

**RESEARCH CORPORATION.** A complete set of samples of the different materials collected by the Cottrell processes, so arranged to indicate the use of processes in particular industries. Special emphasis is laid on the use of the processes in connection with those industries that are vital to the prosecution of the war, such as acid plants, steel works, potash recovery plants, etc. Since the beginning of the war the use of the processes in the sulphuric acid industry has been greatly expanded

and has been successfully applied to the cleaning of hot sulphur dioxide gases from roaster furnaces and for the recovery of acid mist from the exit gases from concentrators. The application of the processes for the cleaning of iron blast furnace gases, which is a successful means of recovering potash, manganese and other valuable constituents. In charge of exhibit: H. D. EGBERT.

**REVOLVATOR COMPANY.** Revolving and non-revolving types of the revolver. This equipment is of unusual interest at the present time in view of the labor shortage for handling materials. The Government requirement of piling materials to the roof of box cars has opened a new field for this device.

**ROESSLER & HASSLACHER CHEMICAL COMPANY.** Chemicals used for electro-plating, case-hardening and heat treating, principally cyanides. There will also be a display of such materials as steel, copper, silver and bronze which are plated, treated and finished with the company's chemical products. In charge of exhibit: Doctor ABEGG.

**ROSSENDALE-REDDAWAY BELTING & HOSE COMPANY.** Illustrations of drives on which the company's belts are used, and showing the conditions which have to be met in various plants. Some of these belts will also be shown in operation to illustrate features of special interest to the chemical industry. In charge of exhibit: WILLIAM L. CLARKE.

**RUGGLES-COLES ENGINEERING COMPANY.** A model of a double-shell direct-heat dryer, together with diagrams of different installations of the various types of dryers manufactured. In charge of exhibit: F. E. FINCH.

**THE R. U. V. COMPANY, INC.** A quartz mercury-vapor lamp and an ultra-violet ray laboratory outfit using this lamp as the source of ultra-violet rays. New features of the outfit will be shown. In charge of exhibit: Mr. RICORD.

**SCHAEFFER & BUDENBERG MANUFACTURING COMPANY.** Indicating and recording gages of all types, gage testers, indicating and recording thermometers, "reform" mercury actuated dial thermometers, hand and stationary tachometers, counters, steam calorimeters, etc. As a special attraction there will be an exact reproduction 9 ft. high of an industrial thermometer which in reality only measures 14 or 15 in. high. In charge of exhibit: H. V. KARLIER F. UNDEUTSCH, A. WEISS.

**SCHAUM & UHLINGER.** Nirtol cellulose extractors and a laboratory centrifugal. In charge of exhibit: C. W. SCHAUM, A. J. CADY, L. GRISCOM.

**SCHUTTE & KOERTING COMPANY.** A display of power plant equipment including injectors for boiler feeds, emergency safety valves, non-returns and a complete line of fuel-burning equipment; apparatus used in the chemical industry for handling corrosive gases or liquids, such as steam jet exhausters and compressors, ventilators, blowers and hard-lead fans, also pumping equipment such as syphons, air jet lifts, centrifugal pumps and automatic blowcases. There will also be spray nozzles of numerous types but particularly the Witclay sulphuric chamber nozzle. A new development since the war began is the Bihn-Jones automatic attachment for blowcases. In charge of exhibit: C. H. KIMBERLY.

**SCHWARTZ SECTIONAL SYSTEM.** Equipment for systematically arranging and instantly locating chemicals,

reagents, samples, and similar materials which may be kept under ideal conditions free from dust and away from the detrimental effects of light.

**SCIENTIFIC EQUIPMENT COMPANY.** An exhibit of laboratory instruments and apparatus and laboratory furniture made by the Central Scientific Company and the Kewaunee Manufacturing Company. In charge of exhibit: O. T. LOUIS.

**ERNEST SCOTT & COMPANY.** Photographs of plant and machinery installed by the company for chemical processes, showing evaporators for various purposes; solvent extraction plant for recovery of grease and oil; caustic recovery plant; glycerine recovery plant for recovering glycerine from fats and oils; glycerine refining plant; soap plant machinery; fish drying plant; fish oil extraction plant; plants for the distillation of water, naphtha, acetic acid, crude pyroligenous acid; apparatus for degreasing skins and hides; plant for the manufacture of electrolytic caustic soda and caustic potash. New features developed since the war comprise equipment for the manufacture of pure ammonia from gas and coke oven spent liquor. In charge of exhibit: H. AUSTIN.

**SEYDEL MANUFACTURING COMPANY.** Benzoic acid and its derivatives which the company is manufacturing at the rate of over 1000 lb. per day. There will also be an exhibit of the company's furamine fur dyes together with a collection of furs dyed therewith.

**SHARPLES SPECIALTY COMPANY.** Super-centrifugal machines, and blueprints showing layouts of processes in which the machines are used. In charge of exhibit: MAX B. MILLER.

**SHAWINIGAN WATER & POWER COMPANY.** An exhibit of the industries at Shawinigan Falls, Quebec, Canada, comprising calcium carbide, carbon electrodes, magnesium metal and powder, glacial acetic acid and allied chemicals. The last-named article has been developed synthetically from calcium carbide since the beginning of the war. There will be an automatic projecting machine showing the views of exteriors and interiors of the various plants and development at Shawinigan Falls. In charge of exhibit: V. G. BARTRAM.

**T. SHRIVER & COMPANY.** Two or three of the most popular types of filter presses in as many different sizes. In charge of exhibit: I. R. E. PERRY.

**SIDIO COMPANY OF AMERICA, INC.** Fused silica ware for laboratory purposes and for use in chemical, scientific, technical and industrial operations. Combustion and pyrometer tubes in all sizes and diameters will be shown, as well as an exhibit of dishes, trays and pipes for the concentration of sulphuric acid. In charge of exhibit: G. H. MULLER, F. H. RUHE.

**WALTER SODERLING, INC.** "Dustite" respirator for protection of workers in cement plants, color plants, lead works and other industries where irritating and poisonous dust might injure the lungs and membranes of the nose and throat. In charge of exhibit: WALTER SODERLING.

**SOUTHERN PINE ASSOCIATION.** The prime chemical products derived from Southern yellow pine, with charts explaining the various chemical processes. The various finishes are illustrated in the railing enclosing the booth. Samples of the chemical products, tools and cups used in the turpentine industry will be displayed;

a model showing the commercial utilization of an average pine tree from the woods to finished products. In charge of exhibit: L. R. PUTMAN.

**SOWERS MANUFACTURING COMPANY.** A special 200-gallon full jacketed kettle with special mixer and outlet, developed for mixing 80-20 amatol; standard laboratory vacuum pans; photographs of various equipment. In charge of exhibit: C. M. DEFORREST.

**F. J. STOKES MACHINE COMPANY.** Rotary compressor in operation making naphthalene moth balls. Small rotary vacuum dryer with patented spiral agitator; dry dust filter and automatic discharge outlets; small laboratory shelf vacuum dryer with condenser and receiver forming a stand; copper vacuum still; automatic combination water still. In connection with war work this company has adapted its compressing machines to the making of pellets of TNT, tetryl, black powder and other explosives. In charge of exhibit: LAWRENCE H. BAILEY.

**STUART & PETERSON COMPANY.** Plain and porcelain lined chemical ware. The principal feature of the exhibit is the 25-gallon cast-iron enameled still representative of those which are built up to a capacity of 1000 gallons. There will also be on exhibit smaller pieces of laboratory ware. During the last two years this company has developed a large line of special apparatus, but particularly sulphonators and steam jacketed vacuum pans. In charge of exhibit: LOGAN B. MORRIS.

**STURTEVANT MILL COMPANY.** Machinery for crushing, grinding, screening, weighing, sacking, dry mixing, elevating and conveying, either in full size or working models. One of the features of the exhibit is the "open door" labor-saving accessibility of Sturtevant machinery. In charge of exhibit: L. H. STURTEVANT, H. A. TOMLINSON, W. T. DOYLE, R. M. GAY, D. KANTOR, E. M. YOUNG, J. H. WAYMAN, W. L. DOTEN.

**SWENSON EVAPORATOR COMPANY.** Evaporators, diffusion batteries, welded digesters, machinery for beet sugar plants. In charge of exhibit, S. W. HIND.

**C. J. TAGLIABUE MFG. COMPANY.** Automatic apparatus for the control of temperature, pressure, time, liquid level, and condensate. The particular controllers which have been developed since we entered the war are the automatic liquid level and condensate controllers for use on evaporators, paper drying machines, tanks and drying apparatus. There will also be an exhibit of indicating and recording thermometers, hydrometers, oil-testing instruments, hydrophants, barometers, etc. In charge of exhibit: L. C. IRWIN, B. O. PALLIN, H. T. CRUAX, T. T. DOUGHERTY, W. W. WHITE.

**TAKAMINE LABORATORY, INC.** A display of chemical specialties: Polyzime, used as a desizing agent in the textile industry; Hirathiol, Ichthylol equivalent, imported from Japan; Arsaminol and Neo-arsaminol, manufactured in this country. Among other imported chemicals shown will be potassium ferrocyanide, potassium ferrocyanide, potassium iodine, potassium bicarbonate, resublimed iodine. In charge of exhibit: C. P. CONCANNON.

**TAYLOR INSTRUMENT COMPANY.** An exhibit in three sections devoted respectively to (A) electrical pyrometers and engraved thermometers and hydrometers; (B) Tycoos industrial thermometers; (C) Tycoos recording thermometers and pressure gages and Tycoos press-

ure and temperature regulators. The pyrometer line will include indicating and recording pyrometers in single and multiple form with special switchboard completely wired and ready for use. Tycos base metal and rare metal thermit couples will be exhibited in a way to show methods of construction. The Fery radiation pyrometer will be demonstrated. Engraved thermometers and hydrometers will be shown in a complete line, with the method of manufacturing demonstrated. Oil-testing apparatus and differential thermometers will form a part of this exhibit. Industrial thermometers will be shown in a wide range of sizes and for a variety of applications. Temperature regulators and controllers will be shown in various types, from the simple controller for maintaining uniform temperatures and ordinary hot-water tanks to the more complicated instruments for regulating temperatures and controlling the time period where the temperature must be advanced by degrees to a predetermined maximum and maintained at that point. Regulators will be on exhibit especially adapted to benzol apparatus. The instruments which have been developed within the past four years, or since the war began, are U. S. Bureau of Mines pattern flash and fire testers for low-burning and high-burning oils. Gasoline distillation apparatus built according to the specifications of the United States Bureau of Mines and American Society for Testing Materials. Tycos differential thermometers constructed in a solid engraved stem pattern.

THERMAL SYNDICATE, LTD. Vitreosil ware for chemical industries and laboratory and research work. This is pure fuse silica in opaque, translucent, and transparent varieties. The features which have been developed during the past year are industrial tubes in 10-ft. lengths; large S bend cooling sets for nitric and hydrochloric acid and transparent tubing and laboratory ware. In charge of exhibit: A. A. MONFRIED, S. L. TYLER, E. J. VANVRANKEN, W. W. WINSHIP.

TOLHURST MACHINE WORKS. Five different types of Tolhurst centrifugal machines having the standard self-balancing feature. The latest type of suspended centrifugal with bottom discharge and 40-in. basket, built for specially heavy duty, will also be shown. The center-flung open-top centrifugal, developed since the war, will be shown in operation. Since the outbreak of the war this concern has developed several types of centrifugals especially designed for the rapid production of munitions. In charge of exhibit: W. C. DUTTON.

UEHLING INSTRUMENT COMPANY. Fuel-saving equipment, CO<sub>2</sub> recorders, combustion recorders, draft recorders. The features of the exhibit are equipment recommended by the United States Fuel Administration. In charge of exhibit: S. W. SMITH.

UNION DYE & CHEMICAL CORPORATION. Samples of dyes, showing the dyeings; samples of dyestuff intermediates and heavy chemicals, the latter being raw products for explosives manufacture which are being supplied by the company to several governments.

UNITED FILTERS CORPORATION. Demonstration of a model of the American continuous suction filter: a large type of filter with approximately 65 square feet of filter area will be exhibited to give an idea of the commercial size machine; an intermediate size of the Sweetland type of filter with a cake capacity of 32 cubic feet

of solids; a small model of the Kelly filter; Sweetland patent metallic filter cloth, and a filter lead of the all-metal type. In charge of exhibit: H. J. RUNYON, JR., A. W. SCHMIDT, C. B. OLIVER.

UNITED LEAD COMPANY. "United" lined products, including lead-lined pipes, fittings, valves, centrifugal acid pumps, lead-coated sheets and coils, lead-lined tanks and kettles. The centrifugal acid pumps, lead-coated sheets and some of the valves have been developed since the beginning of the war. In charge of exhibit: C. B. HOLDEN.

UNITED STATES CAST IRON PIPE & FOUNDRY COMPANY. Exhibit of facilities for manufacturing cast-iron pipes and castings used in chemical and allied industries. In charge of exhibit: H. A. HOFFER, C. D. DONALDSON.

U. S. INDUSTRIAL ALCOHOL COMPANY. A display board showing the many uses of alcohol in the arts and industries. Illustration of the company's plants and methods of transporting raw materials and products. An exhibit will be made of the use of alcohol in removal of carbon from cylinders of explosion engines. The products exhibited will comprise ethyl alcohol, cologne spirits, wood alcohol and refined fusel oil. In charge of exhibit: A. H. LESLIE.

UNITED STATES INDUSTRIAL CHEMICAL COMPANY. An exhibit of the company's products, including acetone, methyl acetate, ethyl acetate, amyl acetate, ethyl methyl ketone and light and heavy acetone oils. Photographs illustrating the extent of the manufacturing facilities of the company. In charge of exhibit: E. H. LESLIE.

VALLEY IRON WORKS. Machinery for the chemical and explosive industries, consisting of autoclaves of laboratory and semi-commercial sizes. These machines will be identical in every particular except size with the large commercial apparatus. In charge of exhibit: THOMAS SENIOR, RAYMOND L. RILEY.

WARNER CHEMICAL COMPANY. A full sized model of the Nelson electrolytic cell for the production of chlorine gas and caustic soda. There will also be on exhibit, a flow sheet of the products manufactured by the WARNER CHEMICAL COMPANY and the base materials from which they come. The principal thing of interest on this is acetic anhydride which prior to the war was almost entirely imported from Germany.

WERNER & PFLEIDERER COMPANY, INC. An exhibit of laboratory sizes of "Universal" kneading and mixing machines; a rapid dissolver, laboratory size, hand driven; a new direct motor-driven laboratory grinder. In operation. These machines will be available for tests or experiments which visitors to the exposition may desire to make. In charge of exhibit: EMIL STAEHLE, A. J. VOLLRATH, C. PLETSCHER, EUGENE SCHILLER, J. C. CALEY, S. D. GRIDLEY, J. J. MEGIERIAN.

ZAREMBA COMPANY. Evaporators. Owing to the nature of the apparatus in which this company specializes, it is impossible to make an advantageous exhibit, hence the display feature is eliminated. In charge of booth: H. E. JACOBY.

ZAVON, INC. An exhibit featuring the use of Zavon, the textile solvent, in the textile trade as an aid in bleaching, softening and dyeing. This is an entirely new product since the beginning of the war. In charge of exhibit: T. W. PRITCHARD, CHARLES S. SAWYER.



# CHEMICAL & METALLURGICAL ENGINEERING

A consolidation of ELECTROCHEMICAL & METALLURGICAL INDUSTRY and IRON & STEEL MAGAZINE

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## Are You a Good American?

EACH good American wants to do his share toward winning the war. If he may not fight or engage in the various forms of war work over there, he wants naturally to have the feeling that he is working for his country here. Through the purchase of Liberty Bonds of the Fourth Liberty Loan, now at hand, the opportunity for just that form of service is given to all.

Whatever the occupation by which one earns his living, it can be turned into war work by way of Liberty Bonds. However indirect its connection with the prosecution of the war may seem, the connection can be made a direct one, if it contributes to the lending of money to the Government. Work produces capital, that is, an accumulation of goods, material riches, results from the daily labor of America. Capital is needed to carry the war to its end. A little taken from the gains of each worker, and set aside for bonds, will make the individual a direct participant in the country's war activities.

No one should miss the opportunity. No loyal citizen, anxious to help defend the United States against the aggression of the enemy, will miss it. Just a little saving, slight self-denial, a cutting off of some of the frills and luxuries of life to which good wages and nation-wide prosperity have accustomed us, will make it possible for every one to lend money to the Government. The widest possible distribution of the Fourth Liberty Loan is desirable on many counts. In the first place, it is the soundest kind of financing to spread securities broadcast. It enlists the active interest of all who buy them for the purpose for which they are issued. Then again, the more people there are who buy these bonds, the more people there are who have thus signified to Germany their intention to work unceasingly for victory. That is the spirit—the national will to win—which even the German people can understand.

If we all buy bonds, we can say to the soldiers who return at the end of the war, "We did our part at home while you were doing yours abroad. Together, we won the war and preserved America."

## Lack of Life in the Rubber Section

THE proceedings of the Rubber Section of the American Chemical Society at its Cleveland meeting were unimportant. Substantially no new information was given out and while problems discussed were of considerable weight, no valuable decisions were reached. The trouble with this section is that most of those who attend its meetings are ready and anxious to

get valuable information but are unwilling to disclose anything of much worth. Many of the gentlemen present could have added to the store of knowledge without difficulty and without real injury to the interests they represented, but they remained silent owing to the medieval attitude of most of the rubber companies.

It does beat all how slow we Americans are to learn that you can't get something for nothing. The business is thriving while rubber is scarce. Every improvement in technique that is introduced is of benefit to the industry at large, and while competitors are expected to compete, they are all in the same boat and they constitute the American rubber industry. There is nothing in the Sherman law to hinder them from co-operation in scientific development, and unless they work together in this respect they are likely to fall behind. The market for crude rubber is open to all civilization and the country that works it up to the best effect will get the trade. Great strides have been made but there is very much to be done still.

It comes to us on the authority of the *Chemical Engineer* of London that Professor Duisberg, of malodorous memory to those who recall the Eighth International Congress of Applied Chemistry, has developed in the Bayer Works in Germany the manufacture of synthetic rubber (methyl rubber) to a present extent of 150 metric tons per month. For several months they have been turning this out and in the meantime they have constructed larger works at Leverkusen with a capacity of 2000 tons annually. The quality is said to be inferior to natural gum but it answers the purpose of helping the Huns. If a similar advance has been made in this country it remains a secret, and we are skeptical enough to believe that it has not been attained.

The Rubber Section of the American Chemical Society needs a good jolt. It should organize itself into a Rubber Institute and get busy. It will not do the industry any harm for the various manufacturers to permit information to be contributed to the common cause; even then they will not know too much. There remains such a vast deal of work to be done that it is unprofitable to sit tight on secrets.

### Jealousy Among the Mighty

**J**EALOUSY is one of the yellowest of human attributes and is not confined to the meek and lowly. On the contrary it aims for the high spots and very often it strikes them. It is the most useful tool of the High Command of the German Foreign Office and for years German agents have been actively fomenting it and encouraging it wherever the voice of the German All-Highest does not sound like the Voice of Divinity.

Some faults we are likely to outgrow as the years press upon us. We are less likely to flare up and shout and make offensive noises in speech than in our salad days. If we find our efforts frustrated, no matter how good the cause may be, we are likely to want to cripple the frustrator or, let us say, the instigator of our whilom inconvenience—when we are all frank and twenty. Speaking conservatively, we are ready to cut his heart out, to tear him limb from limb, to parcel his person for general distribution. With greater maturity we are disposed to address ourselves to overcoming the

difficulties of the task in hand rather than to tear around like a tiger. But jealousy clings on, and there is not one of us, no matter how exalted his position, who is not likely to be touched by it. The colonel of a regiment is rather the natural prey of the passion than the youngest subaltern, and a general is more likely to have occasion for jealousy than a colonel.

It is not many years ago that captains of industry functioned as our minor deities, and the petty jealousies which reigned on the Olympia of Wealth became so widely known that they were recognized along with traditional mothers-in-law, goats, Limburger cheese, tomato cans and other time-honored objects as a source of humor.

But now we are at war and jealousy among the mighty is not funny at all; it is no funnier than treason. Once in a while we come across the evidences of it in high places and it takes more than a little patience to be perfectly good and quiet about it. The only safe thing is to engage in a little earnest meditation every time an important decision is reached. If there is any possibility that jealousy has played a part in reaching a conclusion, the whole subject should be taken up *de novo* in order to banish the poison. If two men are working at the same task and one gets ahead of the other, that is a reasonable cause in these days for congratulation and nothing less, because the work is the sooner completed. We are at war and time is everything. There is not one of us too big to be jealous, and some delays—although far from all of them—can be attributed to no other source.

If we were only conscious of jealousy when it begins to confuse us and make us defective it would not be so dangerous; but as a rule the subject of the trouble is the last one to learn of it. And everybody denies it. On the other hand, there is not a man of responsibility who should not constantly hold himself on guard against it. It is a serious danger. It has frustrated more in the way of achievement than stupidity itself.

### Talking Too Much At the Wrong Time

**T**HE chemical exposition serves the excellent purpose of distributing information among loyal Americans, but we are sometimes disposed to forget that enemy aliens can read, write and cipher. They can also make intelligent observations, and there are thousands of ways to get their information over the lines from Holland, Sweden, Norway and Denmark. Enemy aliens do not wear special uniforms or insignia of any sort, and they do not all speak with a German accent. They are not all herded in concentration camps and they are very active when they are at large.

Chemists engaged in industry are likely to be secretive about their own work. We do not hesitate to criticize this as a fault, more particularly in the short-sighted administrative men who, having the power, forbid them to speak and give out anything but urge them to listen and get something if they can. On the other hand, being pressed and squeezed with secrecy in respect to their own work, they are likely to be gossips about that of others. In fact, scientific men are said to be rather talkative among themselves. This is all as it should be; indeed, we are, ourselves, purveyors of sci-

tific news, and we should be in a bad way if our friends were to lose their curiosity. And we are not charging our friends with indiscretions in speech. We merely know that indiscretions have occurred somewhere, and our present purpose is to caution chemists and engineers as well as to take it to heart ourselves.

We are in the midst of war and the lid is off. It is the nastiest, dirtiest war that ever was fought. There seems to be no bottom to the German's depravity and no portal to his mind save that which may be discovered by his own methods. Therefore with such devices as poison gas in general use, it stands to reason that the only value to some of these outrageous man-killing things is to be there, to paraphrase the late General Forrest, the firstest with the mostest devilment. There is no advantage when both sides employ the same novelties in munitions; the advantage lasts only as long as one side has it and the other has not.

We have been amazed to hear a lot of loose talk going on in regard to what is about to be done, and concerning many inventions in proposed warfare of which the enemy should know nothing. We learned the other day of the almost public congratulations offered to an inventor who had invented an instrument that might be of signal advantage for not over a week, after which the enemy would doubtless prepare himself in a similar manner. The greatest possible secrecy had been observed and yet here was the subject made common gossip, and very likely known at German headquarters by this time.

There is only one thing to do about details of novelties in munitions or chemical or any other kind of warfare that may be under advisement but not yet introduced at the front, and that is to shut up, tight, no matter what we hear. There will be plenty of opportunity to talk about such things after the war.

### Basic Eight-Hour Day in Steel Industry

THE action of the United States Steel Corporation in deciding to establish "the basic eight-hour day" in its plants doubtless means general adoption by the iron and steel industry. An outstanding feature of the decision is that it was reached without any suggestion in that direction by the National War Labor Board. It is related, indeed, that at least a twelvemonth ago there were several operating heads of Steel Corporation subsidiaries who favored the adoption of the basic eight-hour day at that time.

This is a war-time measure in a double sense. On the one hand, it is a long step in the direction of encouraging maximum effort on the part of employees. The workmen will not be disposed to seek shorter hours when they are being paid time and a half for the hours per day in excess of eight, and that means just so much labor kept in the American war machine. On the other hand, the eight-hour day was destined eventually to become quite general in the industry, for the twelve-hour day could not continue indefinitely, and much of the work must perforce be divided into either twelve-hour or eight-hour shifts. If the eight-hour principle were to be adopted at some time, war-time with its attendant dislocations, is a better time than ordinary peace times, when the necessary arrangements would be much more difficult. At some time after the war, perhaps soon,

perhaps far distant, the labor supply will be such as to make feasible or even to dictate, the establishment of eight hours as the day's work, and the change will take the logical form of dispensing with overtime work, with its attendant money bonus. Such a change may still be somewhat difficult, but it will not be as difficult as if the basic eight-hour day principle had not been introduced as a stepping stone.

As the iron and steel industry was organized—or rather unorganized—before the war the introduction of a three-shift system in work where a two-shift system prevails could not have been accomplished with no change in the rate of pay per shift, because an increased wage-cost of 50 per cent would have been involved, and competitive conditions stood as a barrier. The money cost of introducing the basic eight-hour day, on the other hand, is almost insignificant as such matters go now. It means 16½ per cent advance in the day's pay for 12-hour men, and 10 per cent advance for 10-hour men. Some other adjustments may be required for men working less than 12 hours, but the total payroll increase to all employees is not likely to be as much as 10 per cent. In comparison with this, there is the record that during 1916 there were three 10 per cent wage advances in the iron and steel industry, in 1917 two 10 per cent advances, and already this year a 15 per cent advance and a 10 per cent advance, making a total war record of seven wage advances. The eighth is now that involved in the introduction of the basic eight-hour day. The seven advances had approximately doubled wages.

There has been no ground for assuming that after the war the iron and steel industry's wages would either remain at the war-time level or would decline to the pre-war level. Some intermediate ground would be found. In this new alignment the ground will be found at a higher level, in terms of rates per hour, than would otherwise have been the case. The amount of the industry's readjustment, in costs and selling prices, is correspondingly reduced, and that is certainly not disadvantageous.

Within a very considerable number of years, at least, steel will not be nearly as cheap as it was before the war. That will not be altogether an evil. The war has taught men much as to the intrinsic value of materials. Food material, for instance, is on all hands regarded with much more respect than formerly. It is made to go farther, and so with clothing, lumber, practically everything. Steel must be made stronger. If it used to cost 10 per cent of the price to make it 20 per cent stronger it will not cost as much as 10 per cent of the new price, with its higher basis, to make the increase in strength. There was a time when Mesabi ore was mined as cheap as dirt, and transported a thousand miles, by rail, water and rail, for \$2 a ton, other operations being in proportion, and tons of steel were almost no consideration in making a structure strong. In future steel will be made and used more carefully.

These changes enlarge the field of the metallurgist and engineer. There is a fresh demand created upon the metallurgist to improve the quality of steel and upon the engineer to save labor. Jobs that were not the province of labor-saving devices are made so. The production of steel must become still more nearly automatic.



## Readers' Views and Comments

### Synthetic Phenol

*To the Editor of Chemical & Metallurgical Engineering*

*Sir:*—The recent article by Mr. A. G. Peterkin, describing the Dennis Bull synthetic phenol process is very interesting to manufacturers, but the advantages which it is said to offer are open to question.

The value of any process depends largely on the way in which it can be linked with other lines of manufacture to produce or to utilize by-products. It does not usually pay to operate a recovery plant when the by-products can be sold, and where the investment, needed for the recovery plant, could be used for direct manufacture.

The demand for chlorine and its products has kept pace with, and is now even more urgent than that for caustic, and promises at present to continue so indefinitely. The demand for sulphite of soda, and other salts requiring carbonate of soda or its equivalent, is now so great that it would be a mistake to convert it into caustic.

For producing phenol to the best advantage in the United States, a plant should be located where cheap coal and electricity are available, far enough West for a cheap acid and salt, but yet within reach of the market for soda and chlorine products. It would be operated in connection with an electrolytic caustic and chlorine plant, and a contact acid plant able to compete with the zinc by-product. The by-product soda would be used for making sulphite, bisulphite, sulphide, hypsulphite, chlorate, phosphate, or other such salts.

In comparing the processes it should be taken for granted that they are operated with equal skill and all losses, including those due to shipping, storing, and handling should be included in the figures. In the article, the figures given for raw material required are evidently based on the experience in the Barrett plant with the  $\text{CO}_2$  acidification, and do not represent up-to-date practice with the "old" type of process as worked elsewhere.

The excess acid used in the sulphonation should not exceed 60 per cent of the weight of benzol sulphonated, and as there is 10 per cent excess required in the Barrett process, the actual saving is not over 50 per cent. To make this saving requires the handling of 50 times the weight of the sulphonic acid or 200 times this of benzol. As benzol is worth three times the cost of acid, the value of that used in the extraction is 600 times that of the acid to be saved, so a loss in handling of one-sixth of one per cent would offset the saving.

The figures for these losses are not given, but I doubt very much if, when all losses are included, the Barrett process as described can equal the 93 to 95 per cent over all yield now expected in the old process plants.

There is a net material saving shown in acid, lime, soda ash, steam for evaporation, labor, and plant costs, but the salt made contains an excessive amount of sulphate of soda and requires a considerable increase in the caustic needed in the fusion. This again increases

the volume of liquors in the acidification where the most serious losses of the process occur. The process should be modified to remove this impurity by a preliminary separation of the sulphate and the treatment of the resulting mixture of sulphate and sulphonate by the lime and soda process in the usual manner.

When this is done, and all losses figured, this part of the process may still show a saving, especially in a plant where benzol can be had at production cost, but acid and lime must be bought.

For the fusion, the choice of a liquid or dry salt is an old question, and the liquid has been frequently used. Experience shows that yields of over 90 per cent are exceedingly hard to maintain with either a liquid or dry salt, but that 95 per cent, with occasional fusions running 97 to 98 per cent can be obtained with a moist salt in proper condition. With such salt the capacity of drum dryers is very great, and the steam and labor required to run them is more than offset by the saving in time, and fuel in the fusion. The water must be evaporated somewhere, and it should be done where it is cheapest, and does not interfere with other work.

While the acidification by  $\text{CO}_2$  presents no great difficulty to the experienced man, it has given a great deal of trouble in some plants where it has been tried and requires more skill than either acidification with sulphuric acid or  $\text{SO}_2$ , and should not be considered for either a war-time plant or a permanent one, as the  $\text{SO}_2$  obtained from the neutralization of the sulphonic acid with sodium sulphite supplies a large part of the acid required, and a sulphur burner worth a few hundred dollars can furnish all additional gas for a large plant. Of course, in an acid plant, gas from the ore burners is available. The sulphite produced by this is worth more than the caustic and there is a large increase in the weight.

One of the most serious difficulties of the acid and the  $\text{CO}_2$  acidification is the tendency to form emulsions, if too concentrated solutions are used. To avoid trouble, the workmen dilute them to excess. Phenol is very soluble in a solution of phenate or of undecomposed salt, and as the bulk of the liquors is great, a small percentage of phenol in the liquor will represent 10 to 20 per cent of the total phenol. The statement is made that the liquor can be completely freed of phenol and a 4 per cent distillate obtained by distilling with steam. Experiment shows that the vaporization of phenol is a function of concentration and that there would still be phenol left, when the distillate showed 2 per cent, from a liquor containing 2 per cent, which would require the evaporation and condensation of about twenty tons of water per ton of phenol made.

Probably the best method of acidification is to use  $\text{SO}_2$  only, and separate the sulphite as formed. The wet sulphite is saturated with  $\text{SO}_2$  to complete the decomposition of any phenate, and then dried below  $150^\circ\text{C}$ . in a current of steam. Still residues and any sludge formed go in with the sulphite, and the phenol is re-

covered with practically no loss. The distillate and fore-run are used in the quenchers, with the liquor from previous batches. As no water is added except as steam, and there is considerable evaporation in the quenchers, there is no liquor to dispose of, and the sulphite is free from phenol, and in excellent condition for any other use. Owing to the comparatively small amount of water to be evaporated, the cost of the drying is small and it prevents accidental losses such as occur with liquors.

In the matter of labor, any difference would be more in the design of the plant than the process. Labor in most phenol plants at present is higher than it should be, because they were designed by men who did not yet know the essentials of the process and modern methods, and changes in an old plant are hard to make satisfactorily.

In regard to transportation, any statement which includes a movement of raw materials, but falls short of a complete analysis of movements of by-products, is apt to be misleading. In any case it depends on the location of the plant and the average distance of the market.

E. E. HOTSON.

## An Outgo, Not an Income Tax

*To the Editor of Chemical & Metallurgical Engineering*

SIR:—The proposed new sumptuary tax bill before the Ways and Means Committee of the House of Representatives comprehends raising eight billion dollars annually by taxes on clothing of the more expensive grades; on jewelry, automobiles—in fact all luxuries and many necessities. If one of us pays more than \$2.50 for a hotel room, the state will impose a heavy tax, and so on. This tax is a tax on excess expenditure and is planned to inhibit all luxuries and to reduce to a minimum any waste of essentials. By its enforced economies it will go far towards paying the bill for the war, and in its nature, we think is to be preferred to any great increase in the income tax. For is not an outgo tax, stopping foolish consumption, better than an income tax which puts the brakes on production? The state should desire to stimulate incomes and to stop foolish outgo.

This new departure in taxation coming as it does after other new departures suggests the saying rife among sociologists some six years ago that "socialism not on Marxian lines but socialism by taxation is here." We doubt much if the policy of Government socialism by taxation endorsed and sponsored by the Democrats, the party of Jeffersonian simplicity and individualism, will become less marked in the decade following the end of the war, and we believe that the policy of taxing excess expenditures will be in vogue for years. As a tax on outgo rather than on income it stimulates a healthy growth of trade and industry and tends to conserve and stabilize wealth rather than to destroy and scatter it.

Now, these premises and propositions elucidate further the obvious fact that the country where justice, freedom and intelligence rule, will, after the war, be the best country to live in, for the Bolsheviks are not a cause but a result of graft, license and ignorance. Therefore, if the United States is to grow and flourish, if it is to retain its position as a refuge for the oppressed, retaining a capitalistic form of government and the rights

of property with this new Socialism by Taxation, it must have an intelligent government and an intelligent system of taxation. When this is attained capital and labor will harmonize and we can be exceedingly prosperous because of our industrial and psychological security and stability, and we can afford to pay large taxes.

Now this second set of premises and propositions suggests a further line of thought. If taxes be high, interest rates of course will be high, interest being the measure of the productivity of capital. If interest rates be high, capital must be fruitful and there is no better way for capital to fructify than in the chemical and metallurgical industry. Offhand, we can recall a metallurgical plant costing \$6,500 that with \$50,000 working capital made a profit of \$1,000 per day, and another costing \$175,000 that made \$750,000 per annum. While these are startling exceptions, they only prove the rule that by intelligently directed scientific work capital can be made most productive in the chemical and metallurgical industry. Since it does not seem entirely fanciful to believe that after the war the normal rate of interest may be as high as one per cent a month—the actual legal rate at Rome for centuries, when that great empire flourished under the *Pax Romana*—we incline to the opinion that the future high rates of interest will force an enormous growth of applied chemistry. Granting a well and intelligently managed system of government that induces a feeling of peace and security, capital will increase correspondingly fast. And one sign of intelligence in government is a tax on outgo, not on income, such as now emanates from Washington.

"CHEMIST."

## Research Preparedness in the Zinc Industry

*To the Editor of Chemical & Metallurgical Engineering.*

SIR:—The letter of Mr. Eric John Ericson in your issue of August 15, takes issue as to my attitude towards the value of the sulphuric acid industry as a corollary to spelter manufacture.

My attitude is that while the acid corollary may show on paper in normal times a value of a dollar or two a ton of zinc ore, and does in war times show a value perhaps exceeding \$5 per ton, the manufacture is attended with increasing costs of roasting due to the type of fine burners necessary and the character of flotation slimes used as feed, yielding an abnormal degree of dust in flues and chambers. This coupled with fuel and labor costs is perhaps going to change the balance-sheet after the war.

Again I felt that the freight upon the acid to market was a serious item and often decided the location of a zinc smelter and this involved freights on zinc ore.

I spoke in very broad terms, looking ahead and realizing that the zinc industry was about to see radical changes in metallurgical and economic practice. While zinc distillation in modernized form will still continue to be practised near population centres, and thus have a sale for acid, the reason for such location will be because of the market for domestic briquet fuel which will constitute the most valuable corollary in connection with zinc distillation, because it alone will reduce the fuel costs to the lowest figure, which condition will be necessary to meet the coming heavy competition of cheap water power and cheap zinc by-product concentrates in the northwest.

PARKER C. CHOATE.

## Western Chemical and Metallurgical Field

### Great Falls Rod Mill Commences Operations

A NOTEWORTHY event in the progress of Western metal manufacturing occurred early in June, when the new rod mill of the Anaconda Copper Mining Company started operations. This mill is erected at the Great Falls plant on the high ground north-east of the big stack, and is designed for a capacity of 100 tons of copper rods per shift of eight hours. When operating three shifts, the plant may reasonably be expected to maintain a production of 250 tons of finished material daily. At present only one shift is in operation, its output being rods about 0.4 inch in diameter, which are being reeled and stored awaiting completion of the die benches. Partial operation was thus inaugurated six weeks before expectations; complete operations will be instituted within a very short time.

The mill is equipped with a Rockwell heating furnace designed for oil- or coal-firing. The roughing rolls take the regular 4-inch wire bar through nine passes, delivering to a stand of intermediate rolls next in train. At the present time three passes through these intermediate rolls are used to reduce the rod to 0.4 inch. Finishing rolls directly alongside will make sizes from this down to about  $\frac{1}{4}$  inch.

Other equipment about ready for operation consists of a 4-die machine for special sizes and shapes, a 4-die machine for trolley wire, two 10-die machines for small wires, and four stranding machines for making cables, together with the necessary auxiliaries such as pickling tubs, bright-annealing furnace, and brazing furnace. It is expected that the plant will produce a good proportion of the trolley wire and bonds required for present and future western railway electrifications, together with important quantities of copper products for the general electrical and jobbing houses that are located in this region.

### Potash in 1917

THE United States production of potash bearing materials during 1917 is reported in a recent statement from the United States Geological Survey. Three times as much was reported as in the preceding year—it amounted to 126,577 tons of material, containing an average of 26.4 per cent  $K_2O$ , representing 32,366 tons of pure potash, which is practically the amount predicted at the middle of the year by Hoyt S. Gale of the Survey. The average selling price at the points of production was \$4.26 per unit—that is to say, 21.3 cents per pound of  $K_2O$ —making the value of the potash produced during 1917 equal to \$13,791,922. The quantity produced is about 13 per cent of the normal consumption of the country prior to the war, and while it is far from adequate, still the most insistent demands can now be met.

The Nebraska lakes produced nearly half of the entire output, shipping in the neighborhood of 14,500 tons of pure potash. However, this is hardly half the potential production of the plants operating in that field at the end of the year. The discrepancy is an indication of the rapid expansion of the industry. Much of the capacity was not ready for operation before the year was nearly gone. It is a further indication of the

extreme difficulty in the labor, fuel, and equipment supply and the transportation situation.

The potash produced from kelp represents about ten per cent of the total. A large part of this was high-grade potassium chloride, and the balance was kelp char containing 16 to 36 per cent of water-soluble potash. An unexpected shortage on the kelp crop curtailed the production from this source.

The production from alunite was disappointing, but bids fair to be largely augmented in 1918. This is also true for potash from cement plants. In the latter case, eight mills reported a production of 13,582 tons of dust containing 1621 tons of  $K_2O$ . Installations for the recovery of this fertilizing material as a byproduct of cement kilns are going in apace, and it is expected that the output for the current year will be second only to the production from brines. Such plants are particularly desirable, since they recover the material at such a slight cost that they can continue in operation when the selling price of the material has dropped to a very low level.

Minor amounts of potash were recovered from the residue of charred molasses wasted from alcohol distilleries, the waste liquors from beet-sugar manufacturing, and from the stoves and dust catchers at iron blast furnaces. Crude potash is still produced by a number of small operators by the old methods of leaching hardwood ashes. Thirty-six producers, chiefly in Wisconsin and Michigan marketed about 700 tons of material, estimated to contain about 424 tons of  $K_2O$ . Wool washings and organic wastes from several other manufacturing plants also added their quota to the total.

**The Portland Gold Mining Company.**—The Independence Mill was completed about the middle of the past year, being considerably delayed by slow deliveries, at a cost considerably greater than originally estimated. It has been operated continuously since completion and is gradually approaching the expected capacity of 42,000 tons per month. The cost of treating low grade ore at this mill at prices current eighteen months ago, would be materially less than expected when the mill was designed, and consequently it will form a very profitable asset to the company on the return of normal price levels. During the past year 592,995 tons of crude ore and waste were mined and handled. After sorting, this yielded 75,542 tons of shipping ore sent to Colorado Springs, which gave a gross return of \$1,617,406.62 or \$21.40 per ton. The Victor mill handled reject, mill dirt from stopes and development work, and dump ore totalling 236,915 tons, with average values of \$1.762. The Independence mill handled reject and dump ore totalling 236,915 tons, with average values of \$1.762. The net cost of mining and milling amounted to \$1,864,265.61, and the net profits of the company for the past year, as far as mining and milling operations are concerned, were \$666,254.42 (\$768,809.84 in 1916). The mine manager, Mr. F. L. SMALE, makes some interesting observations on the labor situation in the district, as follows: "Early in the year the effects of the war were noticeable in the labor situation, our best miners quietly leaving the district and going to other camps where special inducements were offered for skilled men. This condition has continued, notwithstanding a wage increase that was asked for and granted."



## Cleveland Meeting of the American Chemical Society

**Important Actions by the Council—Large Attendance at Technical Sessions—Successful Symposia on Dyestuffs and Potash—Social Features**

THE annual meeting of the American Chemical Society was held at Cleveland on Sept. 9 to 13. The attendance was larger than was expected, the registration list showing nearly 600 members. At 4 p.m. the Council met at the University Club. In the absence of the president, DR. W. H. NICHOLS, who was detained at home by an injury to his knee, the senior vice-president, DR. H. S. MINER, presided. The several vice-presidents are also respectively chairmen of the various divisions and their rank accords with their seniority as members of the society.

### COUNCIL MEETING

It was reported that the chemical census which is being prepared in cooperation with the Bureau of Foreign and Domestic Commerce will be ready for the printer about December 1 and that it should be ready for distribution about February 1, 1919, at the price of 30c. per copy. Further details regarding this census and other statistics on the chemical industry have already been published<sup>1</sup>.

The editors of the various journals were re-elected as were also the retiring members of advisory committees. In the evening the Council were guests of the University Club at dinner.

### PROMINENT GERMAN CHEMISTS DROPPED FROM ROLL

On Tuesday morning the general meeting was called to order by Vice-President MINER at Hotel Statler at 10 a.m. There was presented from the Council the following preamble and resolution which were unanimously adopted:

WHEREAS the behavior in war of the German people has dishonored them among the enlightened nations of the earth and proved them unfit to associate with civilized men and women, and

WHEREAS Walther Nernst, Wilhelm Ostwald and Emil Fischer have been actively associated with the German Government and its people in their conduct and offenses, now therefore be it

RESOLVED that the said Nernst, Ostwald and Fischer be dropped from the rolls as honorary members of the American Chemical Society and that this act be construed to take effect as of August 1, 1914.

### THE CHEMISTS' PLACE IN WARFARE

Professor A. W. SMITH of the Case School of Applied Science made an address of welcome, which was responded to by Vice-President Miner. The Secretary, DR. CHARLES L. PARSONS, read a paper on The American Chemists' Place in Warfare. He related that toward the end of 1916 he made a trip on behalf of the United States Government to England, France and Italy and that in all these countries complaints were persistent of their loss of chemists and technically trained men, and

that at the time of his visit each of these countries had withdrawn her chemists from the line.

In order to provide as far as possible against scientific and technical inadequacy in this country, the American Chemical Society, through its President Dr. Julius Stieglitz, offered the services and facilities of the Society to the President of the United States, shortly after war was declared. Following this, the Bureau of Mines in cooperation with the Society, prepared a census of the chemists of the country, beginning in February 1917. Over 17,000 chemists have sent their records, qualifications, age, etc., to Secretary Parsons in reply. Additions are being constantly made to this list. Over 50,000 circular letters and 10,000 personal letters have been forwarded from Washington in the correspondence which the census entailed.

The intensity of the need for chemists was noted as soon as the war began and this increases as time goes on. Over 700 with 1100 helpers are engaged in Washington in one government laboratory on gas work alone, and branch laboratories have been established at Johns Hopkins, Harvard, Yale, the Catholic University of Washington, Bryn Mawr, many state universities and in a considerable number of manufacturing establishments. In June 1919 the work was transferred to the War Department. In the meantime the medical, ordnance and other departments have called for more chemists, and the number has been materially increased. The staff is now so organized that assignments are made as needed. The authorized personnel of the Chemical Warfare Service is 45,000 of which a much smaller number are chemists.

Mr. CHARLES H. McDOWELL read a paper on The Work in the Chemical Section of the War Industries Board. He said that the main difficulty with the United States was that it had been called upon to start big business at the top. This had often entailed loss and expense which only time could have avoided; and there was no time. It is evident, he held, that if the war continues much longer the production of certain materials for the open market must be curtailed, which calls for sacrifices from industries as well as of materials. The unanimity with which leaders of industry have met the demands of war, without complaint and in entire willingness calls for the greatest praise. The Board has 18 sections, and representatives of these meet every morning with the chiefs of buying commissions for the Allies as well as with representatives of the U. S. War and Navy departments to consider what it wanted and where and how it may be obtained. The Board itself does no direct buying but it fixes prices to be paid for staple products.

Certain parts of the country are now over-burdened with war contracts. For instance the district between Altoona, Pa., and Norfolk, Va., is now at its maximum economic capacity and no new contracts or new in-

<sup>1</sup>This journal, Sept. 24, 1918.

stalations can be encouraged in this district. The steel situation, said Mr. McDowell, is desperate. There is practically no structural steel that can be produced. Even Government buildings must be erected without it. Dr. Weidlein, acting director of the Mellon Institute and Dr. Moody of the College of The City of New York are among the Board's consultants and the research facilities of the Mellon Institute of Pittsburgh have been placed at its disposal.

DR. GRINNELL JONES, chemist of the Tariff Commission delivered an address on War Disturbances and Peace Readjustments in the Chemical Industries<sup>2</sup>. He said the greatest changes have been wrought in the chemical and metal working industries, and that the Tariff Commission is actively engaged in studying the situations.

#### CHEMISTRY AND SHIPPING

Ships are no longer permitted to seek the most profitable cargoes. The War Board determines what may be brought in and what may not. The advisory chemist on the staff of the War Board is DR. PENNIMAN of Baltimore. An example of something supposed to be needed but finally prohibited is tapioca. Aside from the familiar pudding it was needed for its starch to make gum for postage stamps and nitro-starch, which is now one of the safest explosives. The Post Office Department soon discovered a substitute and after rapid but intensive research, it was found that nitro-starch may be made from cornstarch—which theretofore was utterly impossible—and that the resultant product is better in quality and cheaper to make than from tapioca starch. And the avoidance of importing tapioca provides shipping to carry over and to supply 25,000 men.

There is a great diversion of materials from their normal use into war needs. Thus the fertilizer industry suffers not only from lack of potash, but from nitric and sulphuric acids and ammonia as well. Peace conditions should make great changes in fertilizer production. And he emphasized the fact that the *status quo ante* cannot be re-established in chemical industry.

#### GAS WARFARE RESEARCH

LIEUT.-COL. WILDER D. BANCROFT of the Chemical Warfare Service spoke on "Chemical Warfare Research." It had to do with the great research laboratory for gas service which was established one and a half years ago by the Bureau of Mines and taken over by the War Department on July 1 last. He gave an outline of the general procedure in regard to any given war gas. If a gas is offered as something new it must have certain qualities to receive thorough attention. The substance may be gaseous, liquid or solid, but it must be poisonous, or produce tears to excess or cause nausea or sneezing or it may produce a nose-twisting stench or it may be a smoke with obscuring power. It must be "good" of its class. One milligram per liter must kill a dog in 30 minutes, and if it is a lachrymatory substance it must be effective in dilutions of one one-hundredth of a milligram per liter. The raw material to make it must be available and easy to produce. There should be already established a good method of manufacture, but if the product itself has sufficient merit of wickedness, it is taken up and manufactured even if the only available method be wasteful. It all depends upon

how useful it may be. It must also be fairly stable. The Allies can use material within one to two months after a shell is loaded but our limits against polymerization are of necessity more rigid than those of the British, French or Italians.

The method of procedure, whether the gas be used by the Germans or developed by the Allies or only suggested and considered, is the same. The first step is for the Offense Division to make it. If it is solid it goes to the Dispersoid Division—and we cannot resist a note in appreciation of Professor Bancroft's happy invention of the name of this division. What the Dispersoid Division does with a solid poison gas is explained in true chemical fashion. Then it goes to the Toxicological Section where its degree of toxicity is determined and other properties are observed and recorded. If these reports are favorable it goes back to the Offense Research Laboratory where the best method of production is worked out and then to the Chemical Production Section where it is made in lots of from 50 lb. to one ton. At this point large-scale production may begin either by the Government or it may be assigned to some manufacturer for quantity production.

#### GASES STUDIED BY MANY SECTIONS

In the meantime samples of it have been making the rounds of other laboratories. The Analytical Section (which may have been the first to investigate it if it is a German product) determines the purity and the amounts of it contained in air under given conditions and here also tests are made of its behavior with other materials in canisters. The Pyrotechnic Section determines its stability when fired in shells and the Defense Research Section determines whether new substances must be put into the canisters with it and if so, what they are. It also takes up methods of detection and it may have to develop protective ointments to be used against blisters, etc., which it may cause. The Mechanical Research Section discovers if, with the change in the ingredients of the canister, the type of the canister must be changed. In the laboratory of the Pharmacological Section the general symptoms of its effects are studied and the problem of susceptibility is investigated. It is also the somewhat delicate business of this section to keep especially susceptible men out of the factories in which it is made. The Pathological Section studies in detail the manner in which various organs are attacked by it, while in the Therapeutic Section the task is undertaken to find effective methods of treating gassed men.

Every section reports twice a month, and a vast amount of reports is piling up. These reports go immediately to the Editorial Section in charge of Col. Bancroft. Here they are condensed and incorporated into semi-monthly reports which go to a selected list of persons in America and abroad. Monographs are in process on each subject which contains everything that is known about it, not only from the results of study here but also from the literature and from contributions made from abroad, as well as from captured German reports.

The whole system of the laboratories at the American University, as it is called, is described as very flexible so that each member of the staff may function wherever he is most urgently needed.

<sup>2</sup>Published in this journal, Sept. 24, 1918



## UNIVERSITIES AND CHEMICAL WAR WORK

PROFESSOR EDWARD W. WASHBURN, professor of ceramic chemistry at University of Illinois, but now of the National Research Council, read a paper on The Place of the University in Chemical War Work. He said the U. S. Government will need a great many chemists beyond those now employed and in excess of the normal output of colleges. The source of additional supply is expected to be the Student Army Training Corps. For this purpose the Government will undertake to train recruits of 18 years of age in three grades for the purpose. The method offers the most remarkable opportunity to any young man eligible for war service who is 18 years old and has passed his high school examinations. He may undertake any one of three courses in chemistry, i.e., the one-year, two-year or three-year course. He may go to any one of a number of colleges and study for four terms of 12 weeks each during one year. This will fit him to do routine analysis, and to be a laboratory assistant. The two-year course is designed to fit him for general chemical work in analysis, food, sanitary and technical work and to include the usual courses in chemical engineering. The three-year course is designed to prepare him for research. The study is very intensive and does not include the cultural studies outside of what the student may glean from science and mathematics, and some English in the three-year course. Every twelve weeks he must pass all examinations and no provision is made for failure. Nothing can be made up. If he fails to pass he is transferred to a cantonment for drill in whatever arm of the service men are needed. He receives \$30 a month pay and clothes, board and lodging. The fact is that more chemists are needed than are available and this has been decided upon as the best means for providing them.

The great need is for research. Much is done according to the best means at hand, and a great deal goes on merely because present methods will work. But many of them are far from the best possible methods. A large number are well worthy of scientific study and Dr. Washburn urged upon professors to undertake such problems in their laboratories where the high pressure of the government organizations does not prevail and to set aside their more favorite problems in research for the nonce. There is much to be done in the measurement of physical properties and the study of the chemical nature of materials that cannot be provided otherwise.

An interesting note is also that the U. S. Government now has scientific attachés assigned to the embassies of London, Paris and Rome. Professor Bumstead (physics) of Yale is attached to the embassy at London with a chemist in his staff. Professor W. F. Durand of Leland Stanford University is in Paris while Dr. H. S. Washington, Chemist of the Geological Survey is in Rome with Dr. Edgar Buckingham, a physicist, as his associate. The rank of scientific attachés is similar to those of the army and navy. They are appointed for the collection and distribution of scientific information in international relations. Their dispatches, like others, go by couriers.

## DYESTUFF SYMPOSIUM

At 2 p.m. on Wednesday Sept. 10 the symposium on the chemistry of dyestuffs was held at Hotel Statler.

MR. R. NORRIS SHREVE of the Calco Chemical Co. presided, and in his introductory remarks he made an earnest plea for the prosecution of research. In no phase of applied chemistry are so many by-products developed as in the dye industry and these cannot be neglected. Uses must be found for them and the research laboratory is the only means of discovery. Another point was that American manufacturers have been trained to produce in bulk and to ignore those things which are only needed in small quantity. The function of those engaged in the industry is to supply needs as well as to earn dividends and while the profits on unusually demanded dyes may be negligible, the demand must be met either here or in Germany. Mr. Shreve proposed that the several organizations make each one a number of such products so that there may be the least duplication of effort in unprofitable enterprises and also that the greatest number of such materials be produced.

He urged upon manufacturers to look ahead as far as they can and declared that success would only abide with those who did so. He also emphasized the need of what we have been preaching for years, which is that in the body of final authority over a manufacturing establishment, whether it be its board of directors or its executive committee, there be found at least one member who has chemical understanding and training.

He concluded by announcing that the programs of a number of American dye manufacturers were considerably set aside in order to enable them to make munitions of war.

## AMERICAN PROGRESS IN DYE MANUFACTURE

DR. L. J. MATOS of the National Aniline and Chemical Co. then spoke on America's Progress in Dyestuff Manufacture. He gave the following dates of the discovery of various coal-tar colors which succeeded the discovery of mauve by Perkin in 1856. Magenta was discovered in 1858; aniline black, 1862; nicholson blue, 1862; alizarine (by Perkin) in 1868; cachou de Laval, which was the first sulphur color, in 1873; methylene blue, 1877; azo reds, 1878; propiolic acid, from which followed synthetic indigo after many years, 1880; tartarazine, 1885; primuline, 1887; rhodamine, 1893; and sulphur black in 1895.

Until the outbreak of the war American dyes were at peace with the world, but when German colors were no longer available the troubles came. Makers had to get along with derivatives of benzene and naphthalene because toluene went into munitions and was worth upward of \$10 a gallon. And intermediates had been mostly imported from Germany. What was lacking to make them was the technical training and experience. The problems had to be attacked *de novo* and results, and at first yields, were seldom alike or satisfactory. Materials which had been bought in Germany 99.8 per cent pure were bought here which were 24 per cent, 33 per cent, 28 per cent and 50 per cent pure in successive shipments, the analysis of the last mentioned invoice reading "50 per cent H Acid and 50 per cent secondary products." So that some of the early dyes were off strength and off shade, and what secondary products were, no one could tell, because they were seldom twice alike. In taking up German patents very little enlightenment is discovered, because if, for instance, the product at a certain stage is one which it is practically



impossible to filter, the inventor's description in the patent is likely to read "I then filter"—and nothing more on the subject.

In the meantime great progress has been made. The yields have been brought up to good practice and impurities have been removed so that today there is no inferiority in American-made dyes. In strength and brilliancy of shade, they are, type for type, as good as those which were formerly imported. The company with which Dr. Matos is connected makes 69 different products. The general public is still debarred from the use of toluene which holds back the production of certain colors that are fast to light. These will come as soon as toluene may be used for this purpose instead of for TNT.

Of the 175 dyes now made in America, all are made from American raw materials and these include nearly all the types in use before the war. Among other dyes alizarine (Turkey red) is now produced in quantity sufficient to meet American requirement, and the speaker expressed the belief that the industry would be a permanent one.

#### THE TARIFF AND THE DYE INDUSTRY

DR. GRINNELL JONES, chemist of the U. S. Tariff Commission read a paper on The Production of American Dyes and Coal Tar Chemicals during 1917. The present tariff law on dyestuffs is short but it is none the less complex. It provides a duty of 15 per cent on intermediates and 30 per cent on dyes with a specific duty of 2½ cents per pound on intermediates and 5 cents per pound on dyes. Alizarine and indigo and certain allied materials are excepted from the specific duties. In regard to all other colors and intermediates there is a peculiar stipulation to the effect that after five years the duty on these shall decrease at the rate of 20 per cent per year provided the American production of dyes at that time is 60 per cent of those used in the country. If the country produces less than 60 per cent, the specific duty shall forthwith cease entirely. The critical date is in September 1921 so that it falls upon the Tariff Commission to have this information available at that time. To prepare for it they have reports from 190 manufacturers of whom 12 do not want their names published, chiefly on the ground that they make only for themselves or that they are about to discontinue and do not want to be bothered with inquiries. The Commission is preparing a pamphlet which will contain 178 names and the record of 12 anonymous manufacturers. The Geological Survey has taken the reports of the tar distillers and coke ovens and the pamphlet will also contain the output of crudes of the distillers and stripping plants. The total but not the individual production of materials will be given, except that in cases where the record of the total production would indicate the output of any single manufacturer, they will be omitted. There are 118 firms reporting on 134 different intermediates. The pamphlet will show 5,900,000 lb. beta naphthol and 10,000,000 lb. H-acid made in 1917; hardly any anthracene; the colors will prove to be mostly of the azo group and sulphur blacks, and 300,000 lb. indigo by one maker who was willing to have the figure printed. There were 260,000 lb. of photographic chemicals made. Of synthetic drugs there were made 900,000 lb. acetanilid U. S. P., and 500,000

lb. acetyl salicylic acid. Exclusive of clerks, sales force and others not engaged in manufacture there are 19,643 employees in dyestuff and allied industries of whom 1733 are chemists. The ratio of 8.8 per cent technically trained men is very high for any American industry.

#### DEVELOPMENTS SINCE 1914

DR. J. F. SCHOELLKOPF JR. of the War Industries Board was detained in Washington by official duties but his paper on The Development of the Dyestuff Industry since 1914 was read by Mr. Willard Watkins of the Schoellkopf branch of the National Aniline and Chemical Company. He believes that the problems to be met after the war will be far greater than during the war. The total production in the United States before the war was less than 6,000,000 lb. per year and owing to the nature of German competition the trade conditions were very bad indeed. The business had had a hard experience. When the war began most makers thought it would not last very long and they erected temporary buildings to produce the things that were most needed. These had to be replaced as plans were changed. In the Schoellkopf Works before 1914 they were making some 16 out of the 300 and odd colors in largest use. By January 1, 1916, they were making 40. By 1917 the ordinary needs of industry were beginning to be met with some satisfaction and during that year they produced 46,000,000 lb. of color at a value of \$57,000,000 against \$2,000,000 worth in 1914. Advance would have been impossible without the splendid responses from chemists, engineers and mechanics as well as from foundries and machine shops. Some original research is now under way in the laboratories but the main efforts have been in relation to improvement of quality. This has been so successful that very few colors now fall short of the best German products. Ninety per cent of the complaints today are due to the faulty application of dyes. The dictators of fashion call for shades which involve the use of a mixture of dyes of which some one or two may not be made as yet. Then substitutions of dyes that are not proper for the purpose are made—and trouble follows. Among the best colors he was glad to say that alizarine and fast cotton vat dyes will soon be forthcoming.

He expressed the belief that unless higher duties are placed upon these materials the industry will be seriously jeopardized after the war. On the other hand, if the industry were to receive the protection of high duties for ten years he believed it could thereafter get along without any protection at all.

#### PROGRESS IN APPLYING NATURAL DYES

DR. EDWARD S. CHAPIN of Boston spoke on An Important Factor in Natural Dyestuff. His paper was a scholarly presentation of the chemical structure of the tinctorial bodies of natural dyes, reviewing the studies of Professor Perkin and others. He brought out arguments in favor of certain natural dyes and declared that logwood, if properly dyed upon wool is fast against light and that it will not crock. Dyers preferred coal-tar colors, he said, because they are so much easier to apply. Research is under way and the outlook is promising that certain natural dyes may be so treated as to make them as easy to apply as the synthetic colors.

DR. J. MERRITT MATTHEWS spoke On the Application

of Dyestuffs in Cotton Dyeing. The special nature of cotton and its requirements in this respect were pointed out.

MR. ELLWOOD HENDRICK told of the beginning of the coal-tar dye industry in this country at Albany, N. Y., and of his connection with it as chemical director in 1881-4.

MR. CHARLES R. DELANEY of Hanover, Pa., in discussing the Manufacture, Use and Newer Development of Dyewood Extracts, told with almost aggressive modesty how quiet and unassuming the makers of dyewood extracts had been while all the country had been talking about coal-tar dyes. Nevertheless he declared that they were growing fast; he agreed with Dr. Chapin about the supremacy of logwood on wool in reference to its bloom and richness, and claimed that dyewood extracts were the natural and best colors for silk, wool, leather and wall paper. He said that before the war his firm had shipped large quantities of Flavine to Germany and Switzerland for wall paper. They had sold hardly any in America because they had preferred to save their self-respect rather than complete in the market with German manufacturers. There is, he said, roughly speaking, \$50,000,000 invested in the dyewood industry in this country today.

#### COLOR LABORATORY OF THE BUREAU OF CHEMISTRY

DR. H. D. GIBBS of the Bureau of Chemistry, Washington, described The Color Laboratory of the Bureau of Chemistry. It is not yet finished and part of what is already constructed has been turned over for war work. But when completed it will be a building 150 x 70 containing 9 laboratories, power and refrigeration plants, nitrators, sulphonators, etc. in short a complete small factory. The plans are very ambitious, being no less than the studies of processes and their details for making dyes for the benefit of the general welfare. Although 80 per cent of the staff and of the work is now on war problems, the following is the plan, and, so far as they have gone, the method:

It is aimed to study dye intermediates, dyes, dye methods and medicines. Work has already been done in chlorination, sulphonation and oxidation. Chlorination is effected by means of light catalysts and the studies of sulphonation and oxidation are also made in the vapor phase. As soon as the work in hand is sufficiently advanced separate pamphlets will be published. Such a pamphlet will shortly appear on H-acid. Another study is on the production of phthalic anhydride by oxidation of naphthalene in the vapor phase. A very interesting work is on cymene, recovered as waste from the sulphite pulp industry. The successful nitration of cymene has already been accomplished and the record published in the *Journal of Industrial and Engineering Chemistry*. From this the development of a large series of derivatives is opened up and as many are indicated as there are of aniline. It is especially promising in the field of dyes of which some have been produced already. What part these new dyes will play in industry is an open question but the outlook is promising. Some 2,000,000 gallons of cymene are available annually from the production of spruce pulp. Further studies have been made on the purification of anthracene pressed cake.

The influence of a government laboratory working

over the problems and publishing its findings is likely to be of marked effect. It emphasizes the fact that development along this line is of general public interest rather than an industrial speculation. And although the speaker did not dwell upon the subject, it appears to us as though it would discourage secrecy in industry, and it is usually a good thing to discourage secrecy. In our opinion it is a sign of bad conditions for industry to manufacture in secret and to sell with a brass band. This puts the emphasis upon selling and discourages attention to the art of producing.

#### PROBLEMS IN TESTING DYES AND INTERMEDIATES

DR. E. W. PIERCE of New York spoke on Problems in Testing Dyes and Intermediates. He said the human eye cannot detect a difference of less than 5 per cent in shades although by colorimetric methods this may be brought down to 2 per cent. He laid stress on differences produced by differences in water and said that adulterants such as dextrine often act as protective colloids and slow down the process. He held that we must regard the process of dyeing as one of adsorption and we should bear in mind that we are at all times dealing with problems of colloid chemistry in the dye bath. Referring again to the effect of impurities he recalled the use of synthetic indigotine when it was introduced. The natural product worked well in a large dyehouse under his observation, but the synthetic product, which was pure, gave all sorts of trouble. The goods were uneven and streaky. The fact was it dyed too rapidly, lacking the usual organic impurities which served as protective colloids and thus slowed down the process. The addition of certain organic matter to the bath overcame the difficulty and enabled the dyers to use the synthetic as well as the natural product.

He called attention to the fact that wool differs at the roots from the tops, and that two lots of wool that look very much alike may dye if treated separately, nearly alike but that if dyed together, one lot may rob the other of its color so that part will come out dark and part very light. These differences, he suggested, may be due to the presence of bleached shoddy.

#### QUANTITATIVE VS. ANALYSIS OF DYESTUFFS

MR. ALFRED H. HOLLAND of the Buffalo Works of the National Aniline & Chemical Co. presented a paper on Quantitative Analysis of Dyestuffs which he had worked out in connection with Mr. Willard Watkins in their laboratory. He said there was very little literature on the subject, but that they had found the work of great value in the work in that it enabled them to determine yields. He gave a number of methods. He took issue with Dr. Pierce as to the colloidal nature of dyestuffs; said that the processes seemed usually to proceed as Dr. Pierce described but he knew for a fact that naphthol yellow, for instance, contained crystal water and that indigo, on standing in solution, shifts from a colloid to a crystalline state. No dispute followed, for Dr. Pierce admitted everything and held to his point.

#### DIVISION OF INDUSTRIAL CHEMISTS AND CHEMICAL ENGINEERS

The dyestuff symposium which was attended by upward of 250 persons was continued in the main ball room of the hotel on Wednesday morning, and on the



conclusion of Mr. Holland's paper and discussion the above division convened with Mr. H. S. MINER presiding.

#### SUGAR AND CITRIC ACID

The first paper was by Dr. W. D. HORNE of Yonkers, N. Y., on Valuation of Raw Sugars. He proposed an amplification of the polarization methods in vogue. Raw sugars often contain impurities that remain in the sugars after filtration and thus augment the cost of refining in remarkable measure. They have an important bearing on the value to the refiner of raw sugars. He gave his methods in detail. It was an excellent paper.

Dr. GRINNELL JONES of the Tariff Commission described The Citric Acid Industry. He recited the crude methods in vogue in Sicily and the mechanical devices and stratagems that are current in California. He also gave some of the perplexing problems that are likely to come before Congress in the decision of tariff duties on citric acid. In the meantime, of the two products that are sold in competition, tartaric acid will be produced in decreasing quantities if we have nation-wide prohibition, while the makers of edible lactic acid declare themselves to be marching into the market with their wares at a lively pace. Citric acid is made from cull lemons and the greater the demand for it, the more severe is the grading of the fruit and consequently the better is the quality of the fruit marketed. In Sicily the culls often are as much as 40 or 50 per cent of the crop whereas in California, with greater attention to the trees, the culls are seldom above 10 per cent of the crop.

Professor ALEXANDER SILVERMAN of the University of Pennsylvania described his invention of A New Illuminator for Microscopes, using lantern slides. This was his second paper on the subject showing a number of improvements. We have already described the illuminator in a previous issue<sup>1</sup>.

#### DEOXIDIZING STEEL WITH FERROMANGANESE

Mr. ALEXANDER L. FIELD, at the continued session of the Division on Thursday morning read a paper on The Deoxidation of Steel by Ferromanganese. The speaker discussed the function of manganese in steel and admitted that it is not known. He was convinced that the theoretical reaction of  $\text{FeO} + \text{Mn} = \text{MnO} + \text{Fe}$  does not take place. On the other hand manganese combines with sulphur to form manganese sulphide which is less harmful than the iron sulphide. When steel solidifies it gives off 24 times its volume of gas, and analysis of that from steel which has been treated with the usual amount of ferromanganese and ferrosilicon shows 3.6 per cent Cl, 0.9 per cent O, 30.5 per cent CO, 52.1 per cent H, 0.2 per cent  $\text{CH}_4$ , and 12.7 per cent N. He considered the manganese reaction to be more probably  $\text{FeO} + \text{Mn}_2\text{C} = \text{Fe} + 3\text{Mn} + \text{CO}$ . The paper was one of considerable extent and its content is but partially indicated in the foregoing.

#### WAR'S EFFECT ON COTTONSEED OIL

Dr. DAVID WESSON of the Southern Cotton Oil Co. discussed The Cotton Oil Industry in the War, illustrated with lantern slides. Before the war mills had trouble in getting seed because mill owners could not compare the prices they paid for it or even talk about

them with a view to agreement without the danger of being sent to prison. Now Uncle Sam fixes the prices and if a mill owner does not live up to them he loses his license. Dr. Wesson did not complain; he merely observed that things were different from the way they used to be. The amount of oil per ton used to vary according to the quality of seed. Now 135 lb. per ton must be squeezed out anyway. And owing to the need of linters for nitrocellulose, every ton must furnish 145 lb. of lint which makes it necessary to keep the saws in perfect order. Owing to the demand for fats some 1,700,000 bbl. of other oil has come upon the market. In districts where the boll weevil ravages the cotton fields the farmers have taken to growing peanuts for their oil.

A paper by Mr. J. F. G. HICKS on Yttrium Mixed Metal was read in his absence. He described the metal as burning in the air in a manner similar to magnesium and said that it decomposes water with considerable energy. It is very difficult to prepare and it gives off an odor of something like calcium carbide. He believes it to have value in alloys with other metals and is engaged in more extended experiments which he will report later.

#### GILSONITE SHALES AND GASOLINE

Mr. GUSTAV EGLOFF described the conclusions reached by Mr. Robert Moore and himself on gilsonite. They have been working on shales to determine the amount of bituminous material to be recovered from them. Gilsonite is a pure bitumen found in Utah in large quantities and is used in rubber, lacquers, pipe-coating, etc. It melts at about 300 deg. They distilled it at atmospheric pressure to find the yields of motor spirits or fuel oil and ammonium sulphate available. By destructive distillation they obtained at the rate of 160 gallons of fuel oil of sp.gr. 8.8, or 29.4 deg. Bé. per ton. The ammonia yields were too erratic to report. From the recovered oil they got a gasoline fraction of 20 per cent. But while it has the volatility of cracked gasoline it would not serve on the market in its place. It has a light lemon-yellow color when first distilled which turns to a deep red on standing. This they were unable to remove. It also contains nitrogen, sulphur and oxygen compounds. Their results have but negative value at present because gilsonite now sells at from \$60 to \$70 a ton and it would be ridiculous to think of making fuel oil from it at such a cost. But the shales are on hand and there are reasons for addressing ourselves to the subject of their use with intelligence.

The petroleum supply is growing short. The Geological Survey estimates that the total available oil in the United States was originally 7,000,000,000 barrels. Since 1859 we have taken out 4,000,000,000 bbl. leaving 3,000,000,000 bbl. still to be produced. At present rates our petroleum deposits are likely to be exhausted in 15 or 20 years; therefore we must look around for other sources of supply.

Shale contains many times this quantity. It is held that over 20,000,000 bbl. of oil may be extracted from the Colorado shales alone which contain from 2 to over 90 gal. per ton and may average around 20 gal. and 15 lb. ammonium sulphate. And yet despite the lurid articles in the daily press telling how to get rich quick on shales, and the offers of stock to investors with

<sup>1</sup>Published in this journal, March 15, 1918 and Sept. 28, 1918.



the assurance that they are coming in on the ground floor and that all they have to do is to put up their money to become millionaires, the investment outlook is far from promising. No technical work has been done so far, and the cost figures that the speaker had seen had been based entirely on laboratory experiments. Again oil that is drawn from the earth is still cheaper. We have the 3 billion barrels left to compete and 300,000,000 barrels available in Mexico. The entire problem needs working out. Mr. Egloff doubted if an investment of less than \$100,000,000 would see the industry organized, established and equipped to market its production. He expressed serious doubts as to the wisdom of investing in the shale-oil industry at present except for a long wait.

A second address by the same author was on The Steam Distillation of Gasoline. In this Mr. Egloff argued in favor of straight firing in preference to using steam and claimed a large economy in favor of it.

An abstract was read of a paper by Mr. HARRY F. LEWIS on The Quantitative Estimation of the Important Constituents of Crude Anthracene.

#### GROWING SUGAR CANE UNDER PAPER

Mr. H. E. HOWE of Arthur D. Little, Inc. gave the substance of a paper of Dr. Arthur D. Little on The Eckhart Method of Sugar Production. This consists in what is called "row mulching" under Eckhart patents whereby the rows of young cane are covered with a specially prepared paper which the sharp rigid young sprouts penetrate in growing while the weeds curl up under it and die. In the Hawaiian climate with its high temperature and heavy rainfall the growth of weeds is exceedingly prolific so that the cost of labor in weeding becomes a leading item of expense. By this means 70 per cent of the labor cost is eliminated and an increase of 25 per cent in the yield of cane is obtained. A method to make the special paper from excess bagasse was developed in the Little laboratory and a paper mill for the purpose is in progress of erection in Hawaii.

#### STANDARDIZING ODORS AND STENCHES

Mr. V. C. ALLISON presented a paper for himself and Mr. S. H. KATZ on An Investigation of Stenches and Odors for Industrial Purposes. The use of various substances having high olfactory properties has long been availed of for warnings in mines, to determine the tightness of joints in plumbing, to observe the circulation of ventilation and for other purposes. To aid in determining the best materials for this purpose the authors have constructed what they call an odormeter whereby the degree of concentration may be approximately determined. A sensitive nose on the part of the operator is required. Five empirical degrees of increasing intensity were fixed upon and by this means they were able to divide the materials to be tested into three general groups. Those of the first group become evident to the olfactory sense in dilution of 5 parts per million of air. The second group require 100 parts per million and the third, 1000 parts per million.

So far as we are aware this is the first instrument designed to establish olfactory standards and we sincerely hope that studies on the subject may be continued.

Mr. H. E. HOWE concluded the session by an illus-

trated description of the industrial research and testing laboratory of Arthur D. Little Inc. at Cambridge, Mass., which we have already described in a previous number of this Journal<sup>1</sup>.

#### POTASH SYMPOSIUM

This was held under the auspices of the Division of Industrial Chemists and Chemical Engineers and it was made a part of the general session.

Mr. J. W. TURRENTINE of the U. S. Department of Agriculture spoke on the Experimental Kelp Potash Plant of the U. S. Dept. of Agriculture. Research began in 1910, being instigated by the Bureau of Soils in the belief that other things besides potash were available from it. A Congressional appropriation was finally made and a plant costing about \$100,000 has been in operation since the end of August, 1917. It has a theoretical capacity of 150 to 200 tons daily but treats about 80 tons, owing to difficulties of harvesting. The kelp is stored and dried by direct heat in rotary kilns, the current of heat opposing the run of kelp. In the government plant the kelp is substituted to destructive distillation in vertical retorts, the charred residue containing KCl, iodine and NaCl. This is dissolved and evaporated, the sodium and potassium salts being separated by fractional crystallization. The work on distillation products, which stand between those of wood and coal, is not complete. The results so far are interesting and encouraging but not yet ready for reporting. Under present conditions the plant meets operating expenses.

In regard to the subject of potash in general Mr. Turrentine considered the prospects of the several supplies respectively from Nebraska lakes<sup>2</sup>, Searles lake<sup>3</sup>, kelp<sup>4</sup> and cement dust<sup>5</sup>. The raw material of the Nebraska lakes contains the highest percentage of potassium and this was the source of the greatest supply last year. Although commercially successful at present they are threatened with early exhaustion. On the other hand there appears to be subterranean deposits of brine which are in part drawn upon now. No prospect of great deposits similar to those found in Germany or in Alsace was mentioned in this connection.

Dr. F. W. ZERBAN spoke of A Useful By-product Obtainable in Potash Manufacture. He referred to a decolorizing carbon of very high potentiality obtained from the kelp char. The best results are obtained by carbonizing the unleached char quickly under conditions in which the gases may easily escape.

Dr. W. H. ROSS was absent on military duty and an abstract was read of his paper on The Extraction of Potash from Cement Mill and Blast Furnace Dust. The potash content of cement dust varies from 2 to 20 per cent K<sub>2</sub>O. The main difficulties are involved in the cost of transportation of the dust and in the fact that the potash recombines to form insoluble silicates. This can be made soluble again by digestion under pressure in the presence of lime. Generally speaking 75 per cent of the potash in cement dust is in soluble form.

Mr. H. W. STOCKETTS gave a talk on The Potash Situation. He emphasized the fact that of two factors necessary to food production we had been in the habit of

<sup>1</sup>This Journal, July 15, 1918.

<sup>2</sup>This Journal, Dec. 15, 1917 and Sept. 25, 1918.

<sup>3</sup>This Journal, Sept. 25, 1918.

<sup>4</sup>This Journal, June 1 and Sept. 25, 1918.

<sup>5</sup>This Journal, Sept. 25, 1918.

drawing upon foreign countries. The labor we got from anywhere except the Orient. In regard to the other factor, fertilizer, we drew our potash from Germany, the pyrites for sulphuric acid to make acid phosphate we drew from Spain and the fixed nitrogen we imported from Chile.

The development of the greensand deposits of New Jersey has been progressing on a limited scale. The cost is less than \$1 per unit of  $K_2O$ , obtained by digestion under pressure with lime. There are also in Colorado some ten million tons of tailings from gold mills that contain about 10 per cent of potash concerning which the prospects are favorable. Mr. Stocketts believed that some sort of a subsidy from the Government to prosecute research in this respect is under consideration.

Mr. GRIMWOOD, formerly of the Trona Corporation, was invited to speak. A new company called the Boro-solvay Co. has entered the field organized by the Pacific Coast Borax Co., and the Somet Solvay Co. of Syracuse, N. Y., and is now operating. The speaker is engaged in the construction of a plant for a third company which looks forward to the production of 250 tons daily.

#### SOCIAL FEATURES OF THE MEETING

On Tuesday evening an informal dinner took place at the Hotel Statler at which no speeches were made; but during the meal a most obstreperous Jazz band provided the now popular tumult, thumping and dissonances. After dinner a smoker was held in the same room. The band remained and besides this there were speeches and songs. On Wednesday evening a reception was held at which Dr. CHARLES H. HERTY read Dr. Nichols' presidential address. It was entitled "A Retrospect and an Application" and gave from the writer's personal experiences, an interesting history of the beginning of the American Chemical Society in 1876, and it told of the doubts entertained that a society could be organized upon such a subject as chemistry. Its present membership of over 12,000 was due to friendly coöperation and Dr. Nichols made an earnest and eloquent plea for that kind of working together that looks to the general welfare, declaring that success in its true sense consists far more in making the most of ourselves than it does in the acquisition of property.

On Thursday evening the Society was entertained at the Country Club at a delightful dinner by the Grasselli Chemical Co., and on Friday most of the members who remained made a trip either to Akron or to Wadsworth, Ohio, to visit the industrial establishments at those places. Other excursions to visit the Cleveland sewage plant, the steel industries of the city, and to Oberlin to look over the college and its chemical laboratory, Wednesday afternoon.

In the foregoing we have reported only the general meeting and those held under the auspices of the Division of Industrial Chemists and Chemical Engineers. We have had no opportunity to confer with the authors of the various papers and stand open to corrections for errors and omissions.

A feature of special interest at these meetings is the frequent opportunity for informal discussion which occurs. This has to do not only with current research but one is frequently reminded of research which has

been recorded and forgotten. As an example of this our attention was called incidentally to a paper by Jovitsch, a Russian chemist, recorded some ten years ago either in the *Journal* of the Russian Society of Physical Chemistry or the German *Berichte*; the relator could not remember at the time. Jovitsch passed ethylene and acetylene, in separate experiments, through a heated tube in the presence of a silent discharge. From ethylene he obtained a solid condensation product,  $C_{10}H_8$ , which had strong radio-active properties. From acetylene he obtained a condensation product  $C_{18}H_{12}$ , with still stronger radio-active properties. He was unable to account for all the carbon originally present and he argued from this that along with his condensation products he had obtained a highly radio-active new element. In view of the great need of radio-actives, the experiment would seem worth looking up and confirming.

Other sections in which papers were read were: Agricultural and Food Chemistry, Pharmaceutical Chemistry, Biological Chemistry, Fertilizer Chemistry and Organic Chemistry.

### World's Leading Filters on Exhibition

THE National Chemical Expositions have always been an opportunity for machinery manufacturers and especially for the filter companies to render definite service to the chemical and allied industrial concerns by exhibiting their latest improvements so that the prospective purchaser can conveniently decide which machine is the best for his requirements. Certainly never has the chemical manufacturer had a better opportunity of making the right selection than at this Fourth Chemical Exposition in which the excellence of the filter exhibits surpasses all previous shows. In no place on the globe is it possible to view such an array of filtration machinery. The world's best at its best is here displayed so that the superintendent or the manager in an hour or so gets the several points of advantage in the different competing machines that he could not possibly get in days by interviews with representatives or by poring through the literature of the several companies.

It is becoming more and more acknowledged that of the different types of filters some are better adapted to handle certain materials and others other liquors, such that the manufacturers are recommending different machines for varying kinds of work and the several companies are to a certain extent specializing in specific fields.

With materials requiring a simple dewatering, i.e., the separation of the liquid from the solid with the solid discharged as a transportably dry material it is but necessary to determine if they can be effectively handled in the continuous type of filter which have so advanced in their operating efficiency that they are admitted to be the leading type of machines for this class of work. The Oliver Continuous Filter Company in their Oliver filter, the Industrial Filtration Company in their zenith rotary filter and the United Filters Corporation in their American continuous suction filter are the leading manufacturers of this type machine and each has a comprehensive exhibit making it a simple matter for the buyer to make his decision. If the material cannot be handled in a continuous vacuum machine but a self dis-



charging pressure can be adapted, as is often the case when high temperatures are required, the Sweetland and Kelly filters as put out by the United Filters Corporation or through E. E. Lungwitz, who handles Kelly filters, will be found to be efficient and economical machines. The Atkins Shriver automatic discharging plate and frame filter press is a new type recently developed for which much confidence is felt of its proving in practice to be another type applicable for this duty. This machine will also augment the work of the familiar plate and frame filter presses as shown by the Shriver Company and the Provost Engineering Co. which are still the leading machines for delivering dry cakes which have to be kiln dried or which have to be shipped as discharged from the filter.

In those plants where the material handled requires the solid to be washed free of soluble prior to discharge a modern filter is the rational choice provided the deposited solids are capable of discharge from the filter medium. If a sufficient wash is obtained on passing the cake through an atomized spray wash water without submergence the continuous filters pointed out above offer the best selection. Superintendents will find that the old objection of the spray permeating the entire filter room is now obviated by housing the sprays and much more adequate wash is being obtained by better control of the vacuum during the different operations as well as by using weak liquor washes. For those liquors requiring pressure type filters or those needing prolonged washing periods with the cake completely submerged the Kelly and Sweetland filters are first choice and especially the latter where the cakes can be uniformly built and the excess unfiltered liquor minimized so that the wash water may be turned on directly without draining the excess unfiltered liquor. Materials handled by plate and frame presses are more thoroughly washed when a refiltration of the cake puddled with wash water is practiced although washing type filter presses may be used to effect a superficial wash.

For liquors containing small amounts of a difficultly filtered solid which is a waste product and to which Filter-Cel may be added as a filter aid the Sweetland sluicing type filter has well earned the premier position. In such clarifying problems thin cakes only can be formed and the immense filter area obtained by putting the filter leaves of this machine on close centers as well as the ability to clean the cloths conveniently and without opening the filter account for the popularity of this type of machine.

In handling acid liquors each of the manufacturers are recommending special equipment. The Shriver and Provost Engineering Companies offer their wooden plate and frame filter presses, the Industrial Filtration Company their acid proof rotary filter and their open tank vacuum leaf filters of wood or lead lined construction, the Oliver Continuous Filter Company their acid proof Oliver filter and the United Filters Corporation their lead lined Sweetland filter and acid proof American filter. Cotton and woolen fabrics are the filter media used and if the precaution is taken of keeping the medium wet when the machine is idle so that the acid does not concentrate with the drying of the cloth a good length of life can be obtained.

Alkali liquors were once thought impossible of handling in modern filters but Sweetland's patent metal-

lic filter cloth put out by the United Filters Corporation and the metallic filter cloth, patent on which is soon to be issued, of the Newark Wire Cloth Company have changed this so that it is now practical to handle even the heaviest of caustic liquors with marked efficiency. In some cases a scale formation must be removed by periodic acid washes but the cloth otherwise stands up practically indefinitely.

The art of filtration abounds in "tricks of the trade" so that different methods of operation of a single machine will often vary the efficiency obtained through wide limits. Yet some materials offer such obstinate difficulties that special machines can more effectively handle them, hence the zenith continuous rotary hopper of the Industrial Filtration Company and the continuous sand filter of the Oliver Continuous Filter Company. Each of these machines is primarily designed to handle those liquors the solid content of which is free filtering and of a tendency to rapidly settle. The application of these machines is also proving more and more advantageous as a substitute for centrifugals in drying crystals from the mother liquor.

Some radical improvements feature some of the exhibits and are worthy of note. The United Filters Corporation are showing a new design of hinge on their Sweetland filter which not only is simpler than their previous eccentric hinge but is also capable of more positive and convenient adjustments. Lugs are cast on the rear of the upper half and drilled to accommodate swing bolts which are adjustable at the top. The lower end of the swing bolts terminates in a forked hinge bearing on which the lower half is suspended. Adjustment is made by moving the nuts on the top of the bolts and obviates such accurate machining as was required with the older type hinge. The American continuous suction filter is now being supplied with a receiving pan continuous in the rear of the machine instead of individual pans as formerly built which allows of greater accessibility and better control of the overflow.

The Atkins Shriver automatic discharge filter press has been redesigned so that by use of a friction clutch no excessive load can be put on the driving mechanism and the paddles are being made of cast iron shaped so as to allow the dislodged solid to more easily escape to the central discharge outlet. The paddle shafting has been strengthened so that the paddles travel in a fixed position, thus insuring freedom from the plows digging into the cloth. This machine abounds in unique mechanics and is held to be practically fool proof now.

The acid proof Oliver filter of the Oliver Continuous Filter Company is now equipped with lead plates covering the sides of the machines and as the axis of the filter is located above the maximum level of the liquor in the lead lined pan rigid iron construction is provided without the metal coming in contact with the liquor.

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**Phenol from Mono-brom-benzol.**—It has been generally accepted heretofore that the halogen compounds of benzene were not suited for the manufacture of pure phenol. Mr. HERBERT H. DOW of Midland, Michigan, patents a method of causticizing  $C_6H_5Br$  with dilute aqueous solution of  $NaOH$  at 300 lb. per sq. in. pressure (425 deg. F.) in an autoclave as follows:







## Wood-Waste as a Source of Ethyl Alcohol\*

The Economic Causes for Past Failure in This Industry—Co-operation of Lumber Industry Essential to Success—Technical Problems Solved—Costs at Fullerton, La.

By GEORGE H. TOMLINSON

FOR some years we have been hearing more and more regarding waste wood as a source of ethyl alcohol. The amount which is thus being made, however, is still but a fraction of the nation's supply and within the past few years has not been extended irrespective of the great and increasing demand which the war has developed.

It may be advanced that sufficient capital is available and competent technical skill can be secured; but if the proposition is, therefore, all that has been claimed, the question naturally occurs. Why has more rapid progress not been made? Is the proposition fundamentally unsound, or does it still offer the very considerable possibilities which have been predicted?

We all realize the distance to be traveled between the discovery of a chemical reaction and its successful commercial development and application. In this case, as a matter of fact, one hundred years have already elapsed. The pitfalls to be crossed, both technical and commercial, are legion, and the more unusual, attractive or revolutionary the proposition may be, the more difficult may its pathway become. Premature development and extravagant or unsound exploitation can prostitute an undertaking, no matter how promising it may be, and when this occurs in connection with a process which has not been already established, disaster is invited.

### INDUSTRY DAMAGED BY PREMATURE AND UNSOUND PROMOTION

I think I may safely say that such a condition of prostitution represents the present status of this particular industry and explains to a large extent its present position of apparent stagnation, even at this time when its further development should offer such unusual opportunities.

In this connection the several company flotations which have occurred have been initiated by promoters having no particular interest in the business itself. This has resulted in only a small portion of the rela-

tively large amount of capital which has been raised in connection with the undertaking filtering through for its actual development. Adequate research has not been undertaken, the plants which already have been constructed have been started prematurely in locations having little regard to the commercial conditions involved, all in order that a rapid showing might be realized and a quick turn made by the promoters. Any complete consideration of this aspect of the proposition can only lead to the conclusion that the miracle is that anything has survived. The fact, however, that several million gallons of alcohol have actually been produced from this source, and that at least two plants have been operating more or less continuously over a period of years, irrespective of the technical and commercial handicaps from which they still suffer, justifies the belief that ultimate success is established, and that the undertaking offers much promise for the future.

It was originally assumed that almost every sawmill represented a possible location for the establishment of such a plant. Since there were almost innumerable sawmills at which the disposition of wood-waste was a problem, even constituting in most an element of expense, it was also assumed that this material could be purchased at a purely nominal figure. It therefore seemed logical that favorable contracts for wood-waste could be made, and, having sufficient capital, the company controlling the process could establish an endless chain of plants producing ethyl alcohol, and thus soon secure entire control of the alcohol market.

On this basis and plan the business was projected. It was soon found however, that while there was no question regarding the number of sawmills or the extent of the waste wood which is produced, nevertheless there are very few at which conditions are entirely favorable for the establishment of the extensive plant which the manufacture of ethyl alcohol requires. The life of the lumbering operations may be uncertain, the water supply deficient, labor or transportation operations unfavorable, or any one of a number of such factors may be found which jeopardize success.

\*A paper read at the Fourth National Exposition of Chemical Engineering, Sept. 25, 1918.



The fact that sawdust and all the other forms of waste wood are so bulky and difficult to handle precludes transportation, and therefore confines its processing to the point at which its production occurs. When approached, the lumberman who has a suitable location soon recognizes the advantage which he enjoys, and any outside company wishing to do business must pay his price, and if once established has no other source of supply. It can at once be seen that any large or general development along these lines was impractical and bound to fail.

#### A NEW START MUST BE MADE ALONG DIFFERENT LINES

In the manufacture of our lumber we know that many millions of tons of waste wood are annually produced, and the potential asset which this waste represents is being recognized. If any considerable part of this, however, can be converted into alcohol, there is probably no more important industrial use which it can be made to serve. That this can be done in a limited way has now been completely proved, but in order to greatly extend its application, the development, it would seem, must follow different commercial lines from those along which the start was made.

The process which has been developed naturally divides itself into two very distinct and separate steps. We first convert a certain portion of the wood, amounting to a maximum of about 28 per cent, into soluble carbohydrates which are then separated in the form of a clear solution which normally contains from 10 to 12 per cent. As a second step we have the fermentation and distillation of this product for the production of ethyl alcohol. It is not essential that both of these operations be conducted at one point, since the sugar solution can be evaporated, and then becomes quite the equivalent of cane molasses, which at present constitutes the principal source of our alcohol supply. Molasses, as we know, is transported to, and assembled at, the most favorable locations for alcohol production, there to be manufactured on the largest scale. Applying this same principle we immediately find that the scope of the wood process is greatly extended. Not only can wood-waste be utilized at those comparatively few locations at which suitable conditions for the manufacture and distribution of alcohol are found, but almost every sawmill with an assured capacity for a reasonable period can be considered as a possibility. At the most desirable locations, complete installations for manufacturing alcohol can, of course, be made; at the others molasses plants

can be installed and their product transported to existing distilleries or to new ones at which the product of several such units can be assembled and used.

The investment required for such a molasses plant is small compared with that which the complete distillery involves, and the importance of this can at once be seen in extending the scope of the undertaking. Furthermore, smaller units can be operated economically, less skilled labor is required, and it does not come under the exacting regulations and control of the Internal Revenue Department as is the case if alcohol is produced. Furthermore, if the molasses product is sold to those already engaged in the distilling business, many market and other trade difficulties are removed which only those having experience in the alcohol business fully appreciate and which the smaller producer might be unable to overcome.

#### LUMBERMEN MUST COÖPERATE AND TAKE ACTIVE INTEREST

In order that such a plan may be carried out, however, it would seem that proper headway cannot be made unless the lumbermen themselves assume the initiative, or at least give it their most sympathetic coöperation and support.

In order to operate to the greatest economy, such a plant should preferably constitute a part of the lumber operation itself, being operated under the same management and on the same premises, thus avoiding all unnecessary handling and storing as well as duplication of equipment or staff. In addition to this, the lumberman, controlling as he does the raw material, can alone determine and regulate its most economical disposition and use, and unless he is financially interested in the subsidiary company its supply of raw material can never be fully assured.

The lumbermen, however, are naturally cautious about engaging in enterprises apart from their regular trade. In the past, numerous byproduct ventures which have been taken up in connection with the lumber industry have failed and very few have succeeded. That this has been due either to their being entirely impractical or as a result of incompetent technical advice is probably true, but nevertheless these failures have seriously retarded others from embarking in the line.

In this case, however, the uncertain and costly experimental expense has already been borne by those that have been blazing the trail, and the success of the enterprise from its technical aspects at least is demonstrated.



It now remains for some one to make a fresh start and thus step in and take advantage of the mistakes of the past. If this is done along sound business lines by one of our progressive lumber concerns, complete commercial success appears inevitable. Should it be found that progress along these lines is blocked as a result of patents, those controlling such patents would be well advised to accept an equitable royalty in order that a proper start should be made. Once this step is taken, others will follow and real headway then be made.

#### PRODUCTION OF MOLASSES SHOULD APPEAL TO LUMBERMAN

From the lumberman's point of view, the production of molasses should offer a very strong appeal. While there are at least several profitable uses to which his waste can be applied aside from its use as fuel, the others, as far as I know, demand sorting or selection. In the case of producing molasses or alcohol, any part or all of his waste can be used even including that which constitutes his fuel supply, since the residue left after extracting the sugars, representing 70 per cent of the original amount, is not depreciated in fuel value. In other words, that portion which is actual waste and is being destroyed can be combined with the amount being burned for fuel, and 70 per cent of this total will still be available for power development. In considering and comparing the values extracted, it is therefore necessary to consider also the much larger tonnage which this process utilizes. The cost of production compared with the cost of cane molasses, however, is the vital element upon which this development must ultimately depend.

In June, 1913, the costs given below were obtained in the alcohol plant then operated by the Standard Alcohol Co. at Fullerton, La. The actual cost of this plant at that time amounted to \$456,920.56. Of this sum, about \$200,000 represented the expenditure for the plant and equipment involved in the conversion of the wood into sugar and the separation of this in the form of a solution. The balance was required to provide the necessary plant and facilities for fermenting and distilling the latter and converting it into alcohol.

#### COST OF PROCESSING AT FULLERTON, LA.

Operations were conducted for 22 days at three-quarter capacity. During this time 6125 tons of green waste wood containing 48 per cent moisture was processed, giving a yield of 1,688,600 gallons of sugar solution averaging in strength 10.3 per cent.

The cost of processing this, exclusive of the cost of the wood, but including all other material, labor, power, factory expense and overhead, together with proper allowances for depreciation, amounted to a total of \$5,371.56, or 31.8 cents per hundred gallons of the strength stated. To convert this into molasses, the cost of the equipment for this purpose would have to be added to the cost of the plant and the cost of its operation to that of the product. However, since the residue from the process supplies the necessary fuel, this concentration can be effected at very little cost.

Assuming a concentration of 8 to 1, the resulting 12½ gallons of molasses which one hundred gallons of the dilute solution will yield may be figured at 2.5 cents per gallon or, say, 3 cents including the evaporation. This

is of course a lower figure than that at which cane molasses has been sold in recent years and very much lower than any price which may be expected to prevail in the future. What this price may be is problematical, but 12 cents is probably none too high.

When we compare the fermentable contents of the product of this run with that of cane molasses, the showing is not so favorable. During the month the average production of spirit amounted to only 4.87 proof gallons per 100 gallons of dilute solution. Using this same percentage, a gallon of wood molasses would yield only 0.39 gallons of proof spirit, whereas cane molasses yields practically gallon per gallon. This gives a cost of 7.7 cents for wood molasses to yield the spirit given by a gallon of cane molasses. While even on this basis it appears that a profit is fully assured, the result which this comparison gives is far from representing the best which can be obtained since the quality of this product was poor.

From the figures given it can be calculated that only about 8.5 per cent of the dry wood was converted into sugars which were fermented, although approximately 24 per cent of the wood was extracted in the solution obtained. It has been repeatedly demonstrated, however, on both large and small scale experimental operations that 26 to 28 per cent of the wood can be converted into water-soluble carbohydrates as a result of simple acid hydrolysis, and that under the best conditions over 80 per cent of this is obtainable in the form of fermentable sugar. In place of realizing this result, not over 50 per cent of the water-soluble carbohydrates obtained has actually been fermentable in the product of the plant which I have mentioned, and the average has been less.

#### PATENT CONFLICT HAS RETARDED PROGRESS

It remains to translate such experimental results, depending as they do upon the conduct and control of the chemical reactions involved, into commercial practice. To do this requires little change in the mechanical methods of handling which were used at Fullerton and largely developed by myself. The mechanical efficiency of these is indicated by the very low per-gallon cost which I have given and which there is no reason to believe should be increased in effecting the much more complete hydrolysis which it is easily possible to obtain. That this has not already been done, I attribute principally to patent conflicts which have directed this development along unnatural lines in the effort to avoid infringement and permit exploitation. In undertaking any new installations, however, if full advantage is taken of existing knowledge and the experiences of the past, the production of a wood molasses equal to cane molasses in fermentable value is assured, and at a cost per gallon which certainly should not exceed that of the low-grade Fullerton product which we have considered.

The lumberman already can see a limit to his timber supply and is rapidly being forced, for this reason, to recognize the necessity of conserving all that is left. Nevertheless, he is still burning 50 per cent of his logs either under his boilers or in his refuse destroyer. Every ton of this waste can be made to yield over 30 gallons of molasses without disturbing in any way existing methods of operation, unless it be that of the



expensive destroyer which every large sawmill still maintains. Allowing but three cents per gallon profit on the molasses which can thus be made, this would be equivalent to an additional profit of almost \$2 on a thousand feet of lumber, an amount probably quite equal to the average profit realized on the lumber itself. In this, it would appear that we may have an almost unlimited source of molasses within our reach, which the distiller can readily convert into the highest grade of ethyl alcohol without any, or little modification in the equipment which he already has at hand.

#### OPPORTUNITY FOR READJUSTMENT OF DISTILLING BUSINESS

With drastic prohibition as a probability of the future, as well as the necessity of conserving everything which can be used either directly or indirectly for food, this should offer a means by which the distilling business can readjust itself to meet these conditions, and at the same time provide alcohol in such quantities and on such a basis that its much wider industrial application becomes a possibility, with all the consequent commercial advantages to which this would lead.

With proper coöperation to this end between the lumber and distilling interests, it should be possible to rapidly realize this condition to their mutual advantage, and at the same time release for other use the immense quantities of food products now used for alcohol production.

When the facts which I have attempted so inadequately to present are more fully recognized, and the proposition is taken in hand by those having a vital interest in its development and success, it may be expected to become a business of the greatest magnitude and importance, and wood-waste should become the principal source of ethyl alcohol.

Niagara Falls, Canada.

**Separation of Aromatic from Paraffine Hydrocarbons.**—The addition of some suitable semi-miscible liquids to the mixed hydrocarbons obtained in the distillation of petroleum, to separate the aromatic toluol, bonzol, etc., by selective solution has been one of the important problems of the munition chemist, as no satisfactory direct distillation separation is satisfactory, the vapor pressures of the members of these series not having a sufficiently wide margin for making good fractionations. Liquid sulphur dioxide has been experimented with considerably in laboratory fractionations but is not practical for industrial use. FLETCHER B. HOLMES of Woodbury, N. J. (Assignee E. I. du Pont de Nemours & Co.) has found that dinitrotoluol is a satisfactory extractor and patents its use.

Gasoline containing the aromatic hydrocarbons is mixed in any suitable manner with an equal weight of a nitro-compound—dinitrotoluol being preferable. This mixture, when allowed to stand, will separate into two layers. The lower layer is comprised mainly of a solution of aromatic hydrocarbons with some paraffines in the dinitrotoluol. The upper layer consists of a solution of dinitrotoluol and some aromatics in solution in gasoline. The two layers are separated and distilled, the higher boiling point nitro-compound being readily fractionated from each. The distillation is carried on preferably at a reduced pressure, or by injection

of a current of steam or other inert gas through the liquid; as the separation from the nitro-compound may be more readily effected in this manner. A distillate will thus be recovered from the lower layer having a higher aromatic concentration, while the one obtained from the upper layer will be decreased in aromatics. Upon repetition of the process, the lower layer fractions will increase in their toluol, benzol etc., content, while the upper will decrease in aromatic content until totally extracted. (Aug. 20, 1918; 1,276,219.)

MR. EDWARD A. BARNES of Giant, California, has received a patent on a process for directly nitrating the aromatics in the petroleum distillate. The light distillate is clarified by repeated agitation with 96 per cent sulphuric acid in the proportion of one gallon to the barrel of oil until all the fluorescent bitumens are extracted. The cleaned distillate is then mono-nitrated with a determined amount of a mixture of nitric and sulphuric acids at as low a temperature as possible, when all of the aromatic hydrocarbons are obtained as mono-nitro-derivatives. A mixture of 625 weights of 70 per cent  $\text{HNO}_3$  and 325 weights of 96 per cent  $\text{H}_2\text{SO}_4$  are slowly added in the form of an atomized spray to about 5000 weights of refined gasoline contained in a vessel provided with stirring devices and cooling coils. The temperature is kept as low as possible and agitation continued for four hours, after which the contents are allowed to separate. Three layers are formed, the top one being essentially paraffine oils, the second about one-tenth the bulk of the first consisting of nitro-aromatic hydrocarbons with a small paraffine content, and the third spent acids with not more than  $\frac{1}{2}$  per cent of unused nitric acid—more than this amount indicating that too much mixed acid was used.

The mixture of nitro-aromatic hydrocarbons which represents 10 to 15 per cent of the original amount of distillate, dependent on the oil field from which it was derived, can be fractionally separated in any suitable still and condenser.

Furthermore, it is found that the complex mixture of mono-nitro-derivatives obtained in this process has the property of reducing the freezing point of nitroglycerin and that this property is also possessed by the mixture of di-nitro-derivatives obtained by re-nitrating the mixture of mono-nitro-derivatives with stronger acids at higher temperatures, and that all of these mixtures which range from liquids to solids are extremely suitable for employment in the manufacture of low freezing point explosives. The mixed acid employed for di-nitrating the mixture of mono-nitro-derivatives has a composition of 36 per cent  $\text{HNO}_3$ , 62 per cent  $\text{H}_2\text{SO}_4$ , and 2 per cent  $\text{H}_2\text{O}$ ; the temperature of reaction is 170 deg. F. For tri-nitrating, the strongest acids obtainable are used; 93 per cent  $\text{HNO}_3$  is mixed with oleum containing 20 per cent free  $\text{SO}_3$ , and the temperature is maintained between 210 and 260 deg. F. (July 23, 1918; 1,273,568.)

**German Sugar Production**, according to the *Kölnische Zeitung* is falling off from 28,000,000 tons of sugar beets in 1915 to 18,000,000, 1916; to 17,500,000, 1917. One-sixth of these figures gives the refined sugar tonnage.

# Advance in Industrial Organic Chemistry Since the Beginning of the War\*

A Review of the Expansion in American Organic Chemical Industries Since the War Began—Outlook for Future is Most Encouraging—Disturbed Trade Relations are Favorable to Establishing an Export Business

By SAMUEL P. SADTLER, Ph.D.

MANY ordinarily intelligent people with no special acquaintance with scientific matters will confess to having had the belief that the United States had no established chemical industries at the outbreak of the present great world war, or if we had any, they did not cover the field of what is known as organic chemistry. Organic chemistry was to them the field of coal-tar dyes and synthetic medicines. And was not this the peculiar and exclusive domain of the German chemical manufacturer? We rather think that this expresses the actual knowledge on the subject on the part of our non-scientific newspaper and magazine writers at the outbreak of the war.

However, the elements which go to favor the establishing of a chemical industry are a wealth of raw materials and a market for the manufactured product, and with these the coöperation of intelligent chemical effort and capital. All four of these elements existed in the United States and the result of their coöperation had already been quite effective long before the beginning of the war in giving us flourishing chemical industries based upon organic raw materials and involving applications of organic chemistry. When we recall the great wealth of this country in petroleum and asphalt, in all varieties of coal, in vegetable and animal oils and fats, in cereals of all kinds and in fibres of indispensable character, we would be surprised if flourishing chemical industries had not been established.

## MAGNITUDE OF THE PETROLEUM AND OIL INDUSTRIES

Let us briefly view some of these industrial organic developments as they existed prior to 1914. The American petroleum industry easily ranked as the first in importance in supplying the world with the various products of mineral oil. Of a total annual world's production in 1914 of over 400,000,000 bbl., the United States produced 265,762,000 bbl. or just about two-thirds, while Russia, the next in rank, produced 67,000,000 bbl. or 16.7 per cent of the total amount.

But it is not only the raw material production that is to be considered. By far the larger proportion of this crude oil was refined in the United States and from it were made gasoline, kerosene, lubricating oils in great variety, paraffin and paraffin candles, vaseline and similar products. These products were not alone for the American market but went all over the world.

We also had a great and well developed industry in the extraction, refining and working up of vegetable and animal fats and oils. A peculiarly American industry was the cottonseed oil and cake industry. Hundreds

of mills throughout our Southern States were devoted to the crushing of the seed and the preparation of the cake, while the refining of the oil and the making of the finest edible products was carried out in large plants. The enormous production of lard and lard oil by our great packing companies and the preparation of oleo oil for foreign shipment was also an important and well established American industry. As a side product, the extraction and refining of glycerin had also become well established and the American soap industry was also well developed and a large export business already inaugurated.

The utilization of linseed oil for paint oils and in the manufacture of linoleum and oil cloth had also reached a high development at the hands of American technologists.

## CORN PRODUCTS DISTINCTIVELY AMERICAN

The great naval stores industries involving the production and utilization of American turpentine and resin had also been well developed and many minor chemical industries based upon them. America was also one of the largest consumers in the world of rubber; thanks to the manufacture of all classes of rubber and water-proofed goods and to the utilization for automobile tires, the working of rubber had been extensively developed.

The refining of sugar, in part produced in the United States and the neighboring West Indies and in part from imported European raw beet sugar had become an extensive industry with the most modern of plant equipment and under scientific chemical control.

As America is in a large degree the granary of the world in its production of cereal foods, we had large chemical industries already occupied with the preparation of the special classes of food products of cereal origin. One of the best instances of a distinctively American industry developed from American material is the corn products industry. From the maize or Indian corn is produced corn starch for food purposes and for technical purposes, glucose or commercial dextrose, corn or maize oil and commercial dextrines. This industry has been developed from a distinctively American cereal and on lines quite peculiar to it as an industry of American growth.

Turning to the textile industries we have, as an American production, one of the world's most useful fibres, viz., the cotton fibre. I have already referred to its peculiar by-product, the cotton seed and its utilization. However, we have many important industries utilizing the cotton fibre in which its bleaching, dyeing and other treatment is chemically controlled.

The textile industries using wool and silk as well as

\*A paper read at the Fourth National Exposition of Chemical Industries, New York, Sept. 28, 1918

cotton have however attained a high development in the United States and the chemical side involving the cleansing and after treatment of the fibres had been thoroughly worked out.

The products of destructive distillation remain to be spoken of. Our American wood-distillation industry will be specially presented by another speaker during this Exposition and so I will pass this by. Coal distillation for gas-making had been practiced by the most accurate scientific methods and great varieties of special gas-making processes had been developed. It will be remembered that the Lowe water-gas process was an American invention which has been copied and adapted since in various other countries. However, we were slow to discard the old wasteful beehive oven for coking of coal for by-product ovens which collect the valuable residuals including gas, tar and ammonia. The production of coal-tar crude ingredients was therefore only moderately developed and of what we term the "intermediates" for the color industry, there was scarcely any production.

An American dye industry using imported intermediates therefore existed, but it existed under difficulty and played but a subordinate part in supplying the American market with the dyes required for our textile industries.

#### CAPITAL HAD NOT MADE THE ACQUAINTANCE OF THE CHEMIST

This brief survey shows that it is a great mistake to assume that there were no organic chemical industries existing in this country in 1914 at the outbreak of the war. Nevertheless the general public knew little of the chemist and his actual or potential value to industry or commerce. Capital, which frequently made large investments in mining and similar enterprises, many of which were largely speculative, had not made the acquaintance of the chemist to any notable extent perhaps because the language of chemical reactions was something foreign to his experience or training and hence distrusted. The war came and we soon learned how great a disturbance such a great war could be to the world's commerce in which the United States played a vitally important part. We also learned promptly how chemical industries were the foundation stones for this great commerce. It soon developed that war in its modern form was based upon the chemical activity and scientific development of a country and then the chemist began, as it has been repeatedly said, to come into his own.

Our special topic therefore is to briefly note how our American chemical industries, and in particular those involving organic chemistry, have responded to this war impulse and demand in the four years that have elapsed since the beginning of the war period in 1914.

Our petroleum industry, which we have shown was already in a highly developed state, had important problems at once presented to it. Great as was our refining capacity, it was utterly inadequate to produce in normal course the quantities of gasoline that were required. Besides the growing automobile consumption, the war demands for motor trucks and for aeroplane and tractor engines came as an added load on the industry. Because of the demoralization of the Russian oil production and the German occupation of Roumania,

the whole gasoline supply for the allied nations has to come from America. To meet this demand we have in addition to what may be called "straight refinery" gasoline, blended "casing head" gasoline and "cracked" gasoline. Under the pressure of the great demand, large quantities of volatile hydrocarbons are washed out by suitable solvents or condensed out of natural gas and then blended with heavy naphtha to bring down the gravity to a proper average. Such a gasoline will necessarily have a wide volatility range but is available for most uses of the normal refinery gasoline. Most of the areas producing natural gas are available for this gasoline extraction but it has developed particularly in West Virginia, in Oklahoma and in California. It is furnishing a rapidly increasing amount of gasoline yearly.

The third source of gasoline mentioned is from special cracking processes and it is this class of processes which has been attracting the most interest and giving the greatest promise of large results. The whole subject was discussed from a theoretical and historical point of view in *Bulletin* 114 of the Bureau of Mines by Rittman, Dutton and Dean. Since the date of that publication in 1916, a great deal additional has been published in the journals and much has been done in a practical way. The Burton process adopted by the Standard Oil Co. is now in operation on a large scale in several of the largest refineries of that company; the Rittman process has been tried on a working scale, although not yet developed to a final form for large-scale production; the McAfee process of decomposition in the presence of aluminium chloride as a catalyst has been developed by the Gulf Refining Co. and the Snelling process has also been brought forward.

That heavy petroleum oils can be cracked so as to produce much light oil or gasoline is beyond question, but the problem is to avoid the production of large proportions of unsaturated hydrocarbons which require acid treatment in the product. McAfee claims to avoid this production of unsaturated compounds and that his gasoline requires no acid treatment, but the success of his process is conditioned on the economical recovery of the anhydrous aluminium chloride available for use. Enormous quantities of other special petroleum products have also been called for by reason of war demands, such as high-grade lubricating oils. I had brought to me for testing some time back a "recoil oil," required by the Government for use with heavy guns, that with a high viscosity had to stand a cold test of — 5 deg. F. (— 20 deg. C.).

Then the demands of the English and the U. S. Navy for fuel oil have drawn upon the Mexican oil fields as well as those of Louisiana and Texas and have pushed production to the maximum.

Meanwhile a new raw material has been brought to notice that is capable of adding enormously to our available petroleum supplies in the oil shales of Western Colorado and Eastern Utah, the deposits also being found to some extent in Nevada, Wyoming and Montana. These shales readily yield by distillation a crude oil capable of furnishing gasoline, kerosene and paraffin and in addition large amounts of ammonia, so that sulphate of ammonia may be obtained as a by-product. In *Bulletin* 691B of the U. S. Geological Survey D. E. Winchester has described this occurrence and gives records of distillation. These shales are said to be like



the Scotch shales but richer in oil. With the gradual exhaustion of the oil fields they will prove a welcome addition.

#### VAST INCREASE IN OIL PRODUCTION AND IMPORTATION

The vegetable and animal oil markets have been greatly affected by the war and the industries based upon them have been changed in a revolutionary way in many cases. The first cause may be said to have been the export embargo established by Great Britain upon all glycerine-containing oils with the beginning of the war. Following this came a shortage in the cotton seed crop in 1915 and the introduction of Soya bean culture in the South. As the refined cottonseed oil took more and more the position of an edible oil, commanding correspondingly higher prices. The Soya bean oil took its place for industrial uses, for soap and paint manufacturers and as a constituent of compound lard and oleomargarine. Soya bean cake has also been readily taken up for stock feed and for fertilizer. The Soya bean contains more protein than either cotton seed or peanuts, as much fat as cotton seed, and only one-fourth as much fibre as cotton seed or peanuts.

It has a lower iodine number than linseed oil and is slow in drying, so that it can not completely replace linseed oil in the paint industry but can be admixed with it. Besides the production in the South, which according to Government reports in the year 1917 was from 531,000 acres, we have had an enormous development of the Soya bean oil importations as the following figures will show. Importation for year 1914, 12,500,000 pounds, for 1917, 264,900,000 pounds and for 1918, 336,824,646 pounds.

Most of this coming from Manchuria enters Seattle and other Pacific coast ports. All available storage facilities at Seattle and other coast points have been overtaxed in the handling of this supply.

#### HYDROGENATION GIVES OILS AN ADDED VALUE

Another great development in oil supplies has come from the greatly increased production of peanut oil. This has come to the fore as a salad oil and for soap making. The crop in the United States rose from 3½ million bushels before the war to 40 million bushels in 1916. For 1917, the Government reports shows that 2,277,000 acres were devoted to its culture in the South, and for the year of 1918 it is estimated that in the State of Texas alone 3,000,000 acres will be devoted to it. The importations have also increased sixfold since 1914, now amounting to over 8 million gallons.

A year ago we had no castor beans grown in this country to speak of. Today we have at Government instigation hundreds of thousands of acres devoted to it in Florida and elsewhere, with the product contracted for by the Government. As illustrating the greatly increased demand for oils capable of yielding food products we may also note the remarkable growth in the cocoanut oil and copra importations. In 1914 the importations of cocoanut oil amounted to 74,386,213 lb., in 1918 it had grown to 289,194,853 lb.; of copra for the expressing of cocoanut oil we imported 45,437,155 lb. in 1914 and in 1918, 486,996,112 lb. Similar changes have taken place in the fish-oil markets with the decrease in the menhaden catch, due to the commandeering of fishing boats and scarcity of men to man

them. Through our Pacific ports chiefly are imported quantities of dog-fish, halibut, salmon, sardine, shark, tuna-fish, candle-fish and walrus oils, largely new to the market, while whale oil, seal oil and porpoise oils are, again appearing in large quantities. These fish oils have moreover an added value as sources of supply since the general application of the hydrogenation process, whereby they can be changed into hardened fats without offensive odor and of the greatest value as soap stock and for glycerin production.

#### GLYCERINE AND OILS FOR EXPLOSIVES

With regard to the increased production of glycerine because of the war demand, I have no figures, but it has been very great, so that the use of glycerine in pharmaceutical preparations has been discouraged in order to conserve the glycerine for nitroglycerine production and for export to our allies. About 21 million pounds has been exported in 1918.

In the field of essential oils there are a few items of interest to note. With the study of wood turpentine as distinguished from gum turpentine it has been recognized that spruce-wood turpentine, now a waste product of the sulphite process of making paper pulp, has a peculiar composition. It consists largely of one aromatic hydrocarbon, cymene (iso-propyl-methyl-benzene). On subjecting this to the Friedel and Crafts reaction with aluminium chloride in the presence of an excess of benzene, toluene and cumene (propylbenzene) are formed. The toluene is readily converted into TNT (trinitrotoluene) and the cumene may be oxidized directly into benzoic acid. The work as reported in the *Journal of Industrial and Engineering Chemistry* for May, 1916, is still in a purely experimental stage but it has much promise.

One of the newer uses of essential oils which has particularly stimulated the production in the last few years of pine oil in the South is for the ore flotation process. The concentration of both copper and zinc ores in the United States as in other parts of the world is now effected by agitating the finely pulverized ore with water in the presence of a small quantity of oil. While fatty oils, mineral oils, coal-tar and wood-tar creosotes have been used, certain essential oils have been found to be specially adapted for this treatment. In this country pine oils, both steam-distilled and destructively-distilled have been especially used and quite an industry in these oils has developed. The magnitude of our copper and zinc production is such that although the amount of oil used in this flotation process is relatively small (less than 1 per cent on the ore) the aggregate consumption of oil is very large.

The war demand has greatly increased the call for rubber goods of all kinds, especially automobile tires, and consequently the consumption of crude rubber has grown rapidly. The importations of rubber in 1914 amounted to 132 million pounds but grew to 390 million pounds in 1918. Exports of rubber boots and shoes were valued at \$1,113,495 for 1914 and \$5,774,341 in 1918; the automobile tire exports were valued at \$4,068,639 in 1914 and \$15,128,294 in 1918.

#### VARIED USES OF ORGANIC SOLVENTS

In this connection reference may be made to the greatly increased demand for organic solvents and the

work done to meet this demand. The most important work of this kind is probably the production of acetone and similar solvents from the Pacific Coast kelp by the Hercules Powder Co. and this fortunately we will have specially presented at this time in a paper dealing fully with the subject.

Another promising line is the manufacture of amyl acetate from petroleum pentane recently described in the *Journal of Industrial and Engineering Chemistry* for July, 1918. This work has been carried out at the Mellon Institute in Pittsburgh, Pa. The use of these organic solvents is manifold but we may note the extensive use of pyroxyline solvents and the greatly increased use of lacquers of this description in the last four years. From aeroplane wing dope to artificial leather we have a variety of utilizations; some of these have grown to extensive industries within the past few years.

Closely allied with this industry is the artificial silk industry, one variety of which is made from a nitrated cotton or pyroxylin. Besides this variety we have the viscose variety, the cellulose acetate, and the cuprammonium artificial silk. The development of these products has been very great in this country in recent years, both for films and for artificial silk as a fibre increasingly used in the textile trade.

Industrial alcohol production has developed greatly in the past few years and numerous new plants have been established for its production from a variety of sources. Much attention has been given to a revival of the Classen process for hydrolyzing the cellulose of sawdust and fermenting the sugar produced therefrom. I have no reliable information however as to whether the difficulties which developed when it was first tried in this country some years ago have been sufficiently overcome to make it a dependable manufacturing process although it has attracted much newspaper attention. More reliable are the processes based upon the use of low-grade molasses and cereals of various kinds and a large production, at present taken over by the munition manufacturers, has been the result.

In addition to this direct war use much alcohol is made for denaturing and use in the manufacture of pharmaceutical products. Some 27 denaturing formulas have been allowed by the U. S. Internal Revenue office and these adapt it for use in a wide variety of cases where tax-paid pure alcohol is inadmissible on account of its cost. This form of utilization is not of temporary character as is the use in munitions manufacture but is destined to grow and require an increasing amount of alcohol properly denatured.

#### GREAT DEVELOPMENT OF THE DYE INDUSTRY

We come now to the industry which may be said to be the touchstone of our ability to achieve results under difficult conditions when confronted with an imperative necessity, viz., the building up on American soil from American raw materials with American capital and American chemical effort an independent dyestuff industry. In speaking of the conditions in the United States in 1914, I said that we had a small dyestuff industry, working under trade difficulties, for the most part with imported intermediates. There were, to be exact, five manufacturers, large and small, of dyestuffs in 1914. The tariff census of coal-tar products, as re-

ported for 1917, shows that there were at that time in the United States 81 establishments engaged in the manufacture of coal-tar dyes and 117 firms manufacturing intermediates. While these figures are striking and can not fail to arrest attention, it is only when we look more fully into the details that we get an adequate understanding of the great industrial achievement that has been wrought in the last four years.

First, as to our dependence upon foreign sources, chiefly German, for our dyestuffs at the beginning of the war in 1914. We were then making in this country a bare one-fifth of our needs out of foreign materials and had neither crudes nor intermediates to speak of. Dye imports from Germany in 1914 were valued at \$5,965,537; in 1916 they were valued at \$849, in 1917 \$464,499, and in 1918 at \$3048. The relatively large amount for 1917 represents shipments held at first in Great Britain but released later on appeal. Do we still import any dyestuffs? Yes. There are two reasons for importing from Switzerland and Great Britain mainly certain dye colors.

The new American dye industry did not at once attempt to duplicate the 900 or more supposedly distinct synthetic dyes of the German dealers but took up the most important classes and produced a moderate number of representative dyes, covering as far as possible the coloring or tinctorial needs of the textile trade. Some of the finer shades are still missing, hence the Swiss importations.

The other reason and perhaps the more important one was that Congress, in the enactment of our present tariff law, cut off the ad valorem duty on indigo and alizarine products, which caused manufacturers to leave the production of these very important products until they had covered the need in other groups more fully.

However, synthetic indigo of American manufacture is already on the market and there will be three sources of supply for it in 1918, one of which promises to supply at least one-half of what the American trade will need for the year. Similarly artificial alizarine of American manufacture, made in Brooklyn, in fact, will be available in large quantities from this time on.

Meanwhile approximately three-fourths of the dyestuffs needed are being produced and some colors in such quantity that an export trade has been started. Let us note that for the year ending June, 1916, the exports of all varieties of dyestuffs—aniline dyes, logwood extract and all other—totalled \$5,102,002 in value, but the bulk of these were vegetable colors including logwood extract. In 1917, the valuation of the exports had leaped to \$11,709,287, with an increasing amount of such colors as sulphur black and the simpler aniline colors. In 1918, and this shows the quality as well as quantity of development, the total exports of dyestuffs were valued at \$16,921,388. Of this, total aniline colors make \$7,298,298, logwood extract \$2,339,480 and all other \$7,284,110. It will be noted that the aniline colors alone exceeded in value the dyestuff importations from Germany in 1914.

#### HOW DOMESTIC SHORTAGE WAS RELIEVED

But the main market for which these dyes are being made, and for the permanent relief of which a great American industry has been created is the United States market and the way in which this has been done

is deserving of a more completely detailed examination.

With the shutting off of the foreign sources of supply in 1914, not only was the need of an American dye industry made clear, but the manufacture of munitions and the filling of foreign orders called for coal-tar products. The manufacture of phenol or picric acid and of trinitrotoluol all demanded an immediate supply of coal-tar crudes. So the gas works, the by-product coke ovens and the tar distillers all united for increased and intensive production. I need only refer to the lists of such great companies as the Semet-Solvay Co., the United Gas Improvement Co., and the Barrett Manufacturing Co. as illustrating the achievements in this production of coal-tar crudes. For the increased production of benzol and toluol the Ordnance Division of the War Department has also started to establish plants for by-product coal distillation because of its special needs.

However, for the dyestuff manufacture we go from the coal-tar crudes to the "intermediates." Some of these require very special apparatus for their manufacture and it was these that had not been made in this country prior to 1914. Our chemical apparatus manufacturers (several of whom are very well represented in this Exposition) responded to the call for this apparatus and gradually these important products, mostly new to American trade, were supplied. The tariff census of 1917 states that the production of intermediates for that year was contributed to by 117 firms and that the production amounted to 322,650,531 pounds valued at \$106,942,918. These figures however involve considerable duplication because of the use of some as a starting point in making others. That the amounts of many are very large is shown however by the statement published by the National Aniline and Chemical Co. that their Marcus Hook works has a producing capacity of aniline oil five times as great as the total consumption in this country prior to the war, and that this company is now the largest producer of aniline oil in the world.

Of course the manufacture of munitions, begun on Allied account and continued later by the Ordnance bureau on our own account, means the production of numerous organic compounds on a scale totally beyond any previous experience—picric acid, trinitrotoluol, nitrocellulose and nitroglycerine for smokeless powder, fulminate powders and other preparations are manufactured by tons, but as this is a war industry and not one that will continue we have omitted it from our discussion.

In conclusion, what is the outlook for industrial organic chemistry in the immediate future in this country? I would say that it is most encouraging. The exigencies of the war in Europe have caused a widespread search for independent sources of raw materials to be made and with very satisfactory results in many cases. Our large corporations have established research laboratories with the best up-to-date equipment and have planned real and thorough-going research in a broad intelligent spirit which does not ask for hasty results but emphasizes the wish for thoroughness. Our Government has recognized in a very satisfactory way its need of chemical service and has thus publicly endorsed the fundamental importance of the chemist in industrial achievement. Capital has come forward willingly in support of properly planned

chemical undertakings and thus made the establishment of new industries possible in a way far beyond what had been possible before the war period. Lastly, the disturbed condition of all European trade relations has made it possible for the United States to inaugurate very promising export business in quarters not previously practical or under conditions formerly distinctly unfavorable. These new achievements we have every reason to expect to continue in future and no doubt with added momentum.

### Charging Tar in Gas Producer

A new method of enriching producer gas contained in a description of the "Gasteam Plant at Ford City, Ontario" appearing in *Power* for Aug. 6, 1918, is an account of their success in returning tar recovered in their gas cleaning system to the producer for gasification. At this plant are installed two Smith gas producers, each built in six independently controlled sections, and with a total capacity of 100 tons in 24 hours. This gas producer has an incline grate with a heavy clinker bar at the toe of the slope, all of the grate bars being operated by compressed air. Each section is charged mechanically through an air lock at the top of the fuel bed, which latter is normally at a dark cherry-red heat and maintained at a depth of 5 feet at the top and 7 feet at the bottom of the slope. Exhaust steam is blown under the grate bars, thermostatically controlled so as to regulate the temperature of the blast at 120 deg. F.; too cool and dry a blast means hard clinker, while too hot a blast gives  $\text{CO}_2$  in the gas. The steam is blown into the producer in puffs, two per minute, so that the action somewhat simulates that of the Mond.

Each producer has its own gas-cleaning system in which the hot, dirty gas is first scrubbed in a primary cooling tower which reduces its temperature from 1100 to 120 deg. F. An exhauster, displacing 45 cu.ft. per rotation, delivers the cool gas under 3 pounds pressure to a series of seven tar extractors. These consist of 1½ pounds of spun glass-wool made into a diaphragm through which the gas passes at high velocity, leaving behind its tarry matters which agglomerate into drops and fall into a drain leading to a storage tank.

The stored tar is delivered to five sprays above each fuel bed through a 2-inch line, unjacketed, being blown out of the tank by 880-pound steam. This method is superior to pumping, since the steam blows out the entire system when it is empty, obviating any danger of plugging with solidified tar. About 950 gallons of tar are produced and consumed daily. Little trouble is had if the tar is sprayed evenly over a compact fuel bed running steadily at a temperature between 1000 and 1200 deg. F. Too high a temperature produces fine lamp black which clogs the clean-up system, while if the fuel bed is too cool, the liquid saturates the interstices. The use of the tar reduces the hydrogen and increases the methane content of the gas; it also betters the thermal efficiency of the producer from 8 to 9 per cent. Analyses of typical gases follow:

|                        | No Tar on Bed              |                            | Tar on Bed                 |                            |
|------------------------|----------------------------|----------------------------|----------------------------|----------------------------|
|                        | 28 Per Cent<br>Ash in Coal | 12 Per Cent<br>Ash in Coal | 12 Per Cent<br>Ash in Coal | 12 Per Cent<br>Ash in Coal |
| $\text{CO}_2$ ...      | 4.7                        | 3.8                        | 4.7                        | 4.7                        |
| $\text{CO}$ ...        | 23.9                       | 23.3                       | 22.1                       | 22.1                       |
| $\text{O}_2$ ...       | 0.5                        | 0.5                        | 0.5                        | 0.5                        |
| $\text{H}_2$ ...       | 15.3                       | 12.7                       | 6.2                        | 6.2                        |
| $\text{CH}_4$ ...      | 2.3                        | 5.1                        | 10.5                       | 10.5                       |
| B.t.u. per cu.ft. .... | 161.0                      | 179.0                      | 208.0                      | 208.0                      |





## The Electrochemical Industries at Shawinigan Falls

Description of the Development of Over Three Hundred Thousand Horsepower and of the Varied Industries Attracted by This Resource—Conditions are Favorable for Labor, Raw Materials and Transportation

By HENRY C. RANDALL

SHAWINIGAN FALLS is located in the Province of Quebec, Canada, midway between Montreal and Quebec City, and derives its name from the Indian word indicating the resemblance between their beautiful quill and bead work and the great falls of the St. Maurice River. The city is of comparatively recent origin, having been until 1898 a wilderness, many miles from the nearest railroad. That year marked the commencement of the development of power at the falls of the St. Maurice River, which are 150 feet high at this point and offer what is perhaps the most remarkable natural power development in the world.

Since 1900 the growth of the city has been extremely rapid because with the coming of the Canadian Northern Railway and the Canadian Pacific Railway the products of immense electrochemical plants, which could obtain cheap power near the falls, were able to cheaply reach the world's markets. Twenty miles below Shawinigan Falls lies, Three Rivers, at which point the St. Maurice River enters the St. Lawrence River. Three Rivers is on tidewater, and with its many miles of docks, capable of docking any vessel navigating the St. Lawrence River, is in a position to furnish a remarkably satisfactory export shipping port for the industries which have grown up at Shawinigan Falls.

### POWER SUPPLY

The basis for the electrochemical developments at Shawinigan Falls is, of course, the large amount of hydro-electric power which is available at remarkably low prices. The Shawinigan Water & Power Company, which owns the power developments at this point, has at present installed in its generating stations at Shawinigan Falls and Grand'Mere, Que., 330,000 horsepower, of which 265,000 is electric power, the balance of 65,000 being sold as hydraulic power to certain of the local industries at Shawinigan Falls.

While this amount of power is capable of supplying all of the present requirements of the district, the Shawinigan company further owns the Gres Falls, six miles below Shawinigan Falls on the same river,

at which point 75,000 horsepower can be developed as soon as required. Moreover, at Grand'Mere, nine miles above Shawinigan Falls, provision has been made for the addition of 60,000 horsepower, and as the foundations have been prepared for this additional capacity, it could be obtained upon relatively short notice. The electrochemical industries at Shawinigan Falls are, therefore, assured of an abundance of hydro-electric power, not only for today, but for a considerable time in the future.

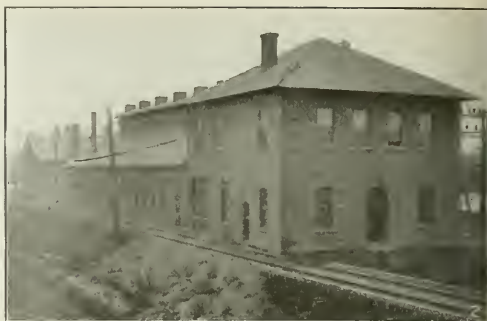
### SHIPPING CONDITIONS

Shawinigan Falls is served by two railroads, the Canadian Northern Railway and the Canadian Pacific Railway, both of which make connection with the National Transcontinental Railway a few miles from Shawinigan Falls. All switching to the various industrial plants is done by the Shawinigan Falls Terminal Railway, so that switching is conveniently and cheaply obtained and the facilities of each railway equally placed before all of the industries.

Three Rivers, twenty miles from Shawinigan Falls, is situated on tidewater, and will offer after the war, when shipping restrictions are reduced, an ideal export shipping port for seven months in the year. During the winter months when the St. Lawrence River is frozen over, export shipments are made from St. John or Halifax.

Three Rivers also offers an ideal shipping port for serving the Great Lakes trade, so that, especially in summer, Shawinigan Falls industries are placed very advantageously with respect to ocean and lake shipping.

While it is difficult to discuss export shipping rates at the present time, it is nevertheless true that in normal times, averaging a large number of the ordinary heavier electrochemical products, a differential of \$2 per ton exists in favor of Shawinigan Falls in summer, and \$1 per ton in winter, over Niagara Falls, which city is taken as representing the greatest electrochemical center on the continent. These differentials will, of course, only apply to products which can be exported to ports reached by the Canadian sailings,



FIGS. 1 TO 8.

Fig. 1—Canadian Electrode Co. Plant. Fig. 2—Shawinigan Electro Metals Co. Plant. Fig. 3—The Northern Aluminum Co. Ltd., Plant. Fig. 4—Canadian Ferro-Alloys, Ltd., Plant. Fig. 5—Shawinigan Developments. Fig. 6—Canadian Aloxite Co. Plant. Fig. 7—Canada Carbide Co. Plant. Fig. 8—Prest-o-lite Co. Plant.

which in general are satisfactory for supplying the European trade. If products are destined for ports not reached by Canadian sailings, it will in general be cheaper to use New York as a shipping point, in which case a differential of between \$1 and \$2 per ton exists in favor of Niagara Falls.

#### RAW MATERIALS

Bituminous coal in normal times is obtained from Nova Scotia, costing normally (pre-war) \$3.20 per ton on wharves at Three Rivers. Anthracite coal is



VIEW OF PORTION OF CHEMICAL SECTION

obtained from United States coal fields. Coke to the amount of about 200,000 tons per year is made at Montreal, largely from West Virginia coal, and can be obtained at very favorable prices.

Petroleum coke to the amount of about 5000 tons per year is manufactured at Montreal, about one-half being made from mid-continent crude-oil and the balance from Mexican crude oil.

Tar to the amount of 3,000,000 gallons per year is produced by the Montreal Gas Company, which is refined and from which 15,000 tons of pitch per year is available.

High grade limestone, quartz and sandstone are available in large quantities near the St. Maurice Valley. Chromium and titanium ores are found and mined commercially within one hundred miles of Shawinigan Falls, as well as zinc, magnesite and other minerals. Excellent shipping and railroad facilities, putting Three Rivers and Shawinigan Falls in touch with the world, make the supply of those raw materials required for particular processes a relatively easy problem for the manufacturer.

#### LABOR CONDITIONS

The St. Maurice Valley is essentially an agricultural community, and as it is largely populated with the thrifty and home-loving French race, there is available on the markets of the industrial centers food products at very fair prices, which is an essential condition in maintaining stable labor conditions. The large families which are common in the Province furnish practically all of the labor required in the industrial centers, and this labor, being French and thrifty, settles down and readily becomes a permanent part of an industrial community.

The amount of labor available in the Province is very

large and is of the kind adapted to industrial work, to which statement the large New England industrial centers of Manchester, Fall River and Lawrence bear witness, as the population of these cities is largely made up of French-Canadian people from the Province of Quebec. It is remarkable that in spite of present-day conditions no strikes or other great evidences of labor unrest have ever been found in the Shawinigan Falls-Three Rivers district. The natural traits of the French people, their thrift and frugality, make labor conditions in the St. Maurice Valley exceptionally satisfactory to the manufacturer.

#### GROWTH OF SHAWINIGAN FALLS

The first electrochemical industry to establish itself at Shawinigan Falls was the Pittsburgh Reduction Company, now the Northern Aluminum Company. Soon afterwards the Canada Carbide Company was started, and in 1905 the Belgo-Canadian Pulp & Paper Company built their first mill. These industries expanded rapidly to many times their original proportions, but no other industries were established at Shawinigan Falls until 1914.

During this period a very large market for the power generated by the Shawinigan Water & Power Company was built up throughout the Province of Quebec, transmission lines being built to serve all the larger cities of the Province and over a hundred of the smaller towns. In 1915, however, a very large addition to the generating capacity of the Shawinigan Company was completed, and this, with the great demand for power existing throughout the country and the inability of manufacturers to obtain power, made the growth of Shawinigan Falls extremely rapid from that time on.

The population of Shawinigan Falls in 1912 was about 8,000; in 1918 its population had increased to



FRASER BRACE CO.'S ELECTRIC FURNACE PLANT

14,000. This great increase in population was brought about by the influx of labor from the surrounding territory for the new electrochemical plants constructed since 1915, descriptions of which are given below.

The Northern Aluminum Company is located outside of the electrochemical district but adjacent to the power developments of the Shawinigan Company. This location was chosen on account of the fact that the Aluminum Company utilizes hydraulic power for their



works rather than the electric power of the Shawinigan Company, although a considerable amount of electric power is now purchased by them.

Their works, of an extensive nature, cover about fifteen acres of ground and contain, beside the reduction rooms for the production of aluminium, an ingot room and a rolling mill and a wire-drawing and cabling plant.

The Canada Carbide Company occupies some fifteen acres of land in the industrial district. The company



GRES FALLS

employs some 500 men and manufactures calcium carbide and acetylene gas only and utilizes about 50,000 horsepower.

The Shawinigan Electro Metals Company, whose plant was constructed and put into operation in 1915, produces metallic magnesium in many forms and occupies about five acres with their various processes. They utilize about 2500 hp. in both alternating and direct-current furnaces.

The first plant of the Canadian Electrode Company was constructed in 1915, but since that time two additions to the plant have been made, so that the present capacity is about four times the original capacity. This company manufactures the larger sizes of carbon electrodes for electric furnaces and have an output of about 30 tons per day. The majority of the output is used in Shawinigan Falls, although a considerable tonnage is exported.

The Canadian Electro Products Company manufacture acetic acid, acetaldehyde, paraldehyde, acetone and other similar products from acetylene gas supplied by the Canada Carbide Company. This plant, while primarily constructed for the purpose of supplying acetone and acetic acid to the British Government, has so demonstrated its possibilities that it will continue to be one of the most important industries at Shawinigan Falls when the war is over.

The Prest-o-lite Company constructed in 1917 a plant for compressing acetylene gas for charging Prest-o-lite cylinders. This gas is purchased from the Canada Carbide Company, near whose plant the Prest-o-lite works are located.

Fraser, Brace & Company in 1917 erected a small electric furnace plant of about 1000 hp. for the manufacture of low-phosphorus pig iron. This plant has been very successful and is now being expanded into a considerably larger industry.

In 1917 the Canadian Aloxit Company, a subsidiary of the Carbide Company, erected a plant covering about

fifteen acres of land near the upper end of the electrochemical district. In these works the company utilizes over 20,000 hp. for the production of such electric furnace products as aloxite, carborundum and ferrosilicon.

During the summer of 1918 the requirements of the United States Government for acetic acid led to the establishment of a plant practically duplicating the Canadian Electro Products Company's plant and erected adjacent to the same. This plant, owned by the American Electro Products Company, will be operated by the Canadian Electro Products Company for the production of these products on behalf of the United States Government.

The latest addition to the Shawinigan electrochemical district is the Canadian Ferro-Alloys, Limited, who have constructed a plant near the Canada Carbide Company for the manufacture of ferrosilicon, and utilize some 10,000 hp. for this purpose.

While not electrochemical, two industries in the Shawinigan district are worthy of mention on account of the large amount of power they consume—the Laurentide Company at Grand'Mere utilizing 28,000 hp. for the manufacture of paper and pulp, and the Belgo-Canadian Company at Shawinigan Falls utilizing 18,000 hp. for the same purpose.

#### GENERAL CONDITIONS

The St. Lawrence Valley being tempered by the large mass of water moving from the Great Lakes to the sea has a very steady and pleasant climate. The Shawinigan district has a mean annual temperature of about 50 deg. Fahrenheit, the days being hot in summer but the nights cool. The winters are rather long and cold but the air is dry and great variations in temperature do not take place rapidly, so that to many the winter season is the most enjoyable of all the year.

Shawinigan Falls, like other large, rapidly growing communities, is somewhat hampered at the moment by



THE CANADIAN ELECTRO PRODUCTS CO.

the lack of housing facilities, but houses are being built rapidly and will no doubt keep pace with the increasing population. As an indication of the stability of the labor, it may be noted that a great number of the houses in Shawinigan Falls are owned by the workmen themselves.

There is a Technical Institute in the city having some 150 students and equipped with fine modern laboratories housed in modern buildings. This institute offers a means of education to the younger men in order that they may be better fitted for the industries

existing in the community, and its night courses, which are well attended, aid workmen to become more useful and to become foremen and superintendents.

As the community is quite new, large amounts of land are available for industries, and in general, sites may be found lying between the two railroads so that siding facilities may be had on each. There is no difficulty



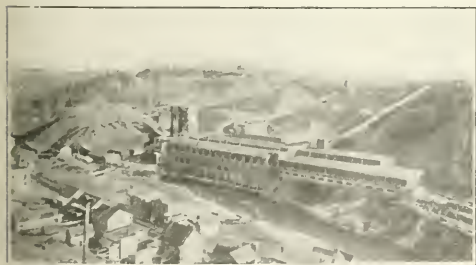
LAURENTIDE POWER HOUSE

in obtaining water from the river for industrial purposes, and this water is of such character that it can be used for the majority of industrial works.

The St. Maurice River water is not used for drinking purposes below Shawinigan Falls, and as the salt sea water is met a few miles below Three Rivers, very little, if any, objection can exist to stream pollution from industrial plants.

#### SHAWINIGAN FALLS—THE ELECTROCHEMICAL CENTER OF CANADA

If we examine the reasons which have made Shawinigan Falls such an important electrochemical and in-



BELGO CANADIAN PULP AND PAPER CO.

dustrial center, we find that they may be summarized as follows:

1. Large amount of power actually available at low prices.
2. Cheap labor of a very satisfactory character.
3. Low import rates for ocean-borne materials.
4. Low export freight rates.
5. Reasonable coal costs.
6. Raw materials near at hand.

These influences, which have built up the Shawinigan Falls of today, will be just as active in the future, and as a result the number and size of the electrochemical industries at Shawinigan Falls must increase rapidly. With 100,000 hp. now available as fast as

plants can be erected to utilize it, and with several hundred thousand horsepower yet untouched, the district offers a strategic location for serving the export market, the future basis of business.

At the present time, Shawinigan Falls is one of the few localities in the country where power in quantity can be obtained quickly and cheaply, and where the necessary labor for plant operation can be obtained without excessive importation. With these present advantages and future possibilities, the Shawinigan Falls of the future will doubtless continue to be the electrochemical center of Canada, if not of North America.

Montreal, Canada.

### Doping in Aircraft Works

The annual report of the Chief Inspector of Factories and Workshops for 1917 [Cd. 9108, 3d] contains a special report on "Doping in Aircraft Works" by Mr. S. Smith, Dangerous Trades Inspector, of which the following is an abstract:

During the period in which dopes containing tetrachlorethane were in use 70 cases of toxic jaundice, including 12 deaths, were reported. A standard of ventilation for dope rooms of 30 changes of air per hour was adopted with good results, but in September, 1916, the use of tetrachlorethane was discontinued. The new dopes containing acetone (diethyl ketone), acetone substitutes (impure mixtures of dimethyl ketone, methyl ethyl ketone and higher homologues), and benzol, also the varnishes containing amyl acetate, still gave trouble as regards nauseating smells, and it was found necessary to maintain the same high standard of ventilation as before. Complaints have been received that where the dopes were used intermittently without mechanical ventilation, the effects from the fumes were more noticeable than those from the older poisonous dopes, and this is especially true where large aeroplanes have their fuselage doped in the erecting shops where no system of artificial ventilation can be applied. As far as possible the fuselage components are being doped before assembly, in properly ventilated rooms, as in the case of wings and planes. The use of sprays instead of brushes gives rise to excessive fumes and mists, so that it is still more necessary in such cases to have efficient ventilation.

### Asphodel as a Source of Alcohol

*Aphodelus ramosus*, which contains much starch in its tubers, grows as a common weed (porrazzo) in many parts of Italy; in fact, it has been called "the plague of the Mediterranean." At one time it was cultivated as a source of industrial spirit, but, owing to difficulties in the rectification, the culture was abandoned. If these difficulties could be overcome Italy would be able to considerably increase her home supply of spirit, for it is claimed that every acre of asphodel plants yields 17,350 lb. of roots from which not less than 107 gallons of alcohol could be obtained. When the manufacture of porrazzo was carried out in Algiers the residue from the distillation was used successfully in the production of paper, but it could also be used directly as a cattle food. —(*Annal. d'Ingegn. e d'Archit.*)

# Alcohol in the Arts and Industries

## Government Restrictions Surrounding the Manufacture and Sale of Alcohol Restrict Its Legitimate Uses in Industry—a Brief Review of the Wide Use of Alcohol

By E. H. LESLIE, Ph.D.

**T**WENTY years ago a joint select committee of the Congress of the United States submitted the following statement as part of an official report:

The uses of alcohol other than as a beverage are more largely and widely extended than is supposed. But while the use of alcohol as a beverage is purely voluntary, its employment for all other purposes is legitimate, beneficial, and necessary. No article entering into manufacture or the arts, whether of domestic or foreign production, performs more legitimate or beneficial functions. There is scarcely a manufacturer in the country who does not use alcohol in the production of his goods to a greater or less extent.

Since that statement was made, its force has been many times multiplied. A large number of new uses have been found for the commodity, and a variety of new products have been produced in the manufacture of which alcohol is a necessity. Industrial alcohol is now produced in large and ever-increasing quantities. Table I, taken from the report of the Commissioner of Internal revenue for the fiscal year ending June 30, 1917, shows the rapid increase in the production of industrial alcohol of denatured grades.

TABLE I—PRODUCTION OF DENATURED ALCOHOL

| Fiscal Year | Number of Denaturing Warehouses | U. S. Gallons, 90 to 95 Per Cent Alcohol |
|-------------|---------------------------------|------------------------------------------|
| 1907        | 8                               | 1,780,276.35                             |
| 1908        | 12                              | 3,321,451.73                             |
| 1909        | 12                              | 4,556,418.85                             |
| 1910        | 12                              | 6,079,027.10                             |
| 1911        | 14                              | 6,881,129.86                             |
| 1912        | 14                              | 8,094,515.00                             |
| 1913        | 21                              | 9,831,658.54                             |
| 1914        | 25                              | 10,404,975.59                            |
| 1915        | 23                              | 13,986,468.77                            |
| 1916        | 33                              | 46,679,106.38                            |
| 1917        | 44                              | 55,679,597.63                            |

In addition to the denatured alcohol recorded in this table, a considerable quantity of tax-paid 95 per cent alcohol is consumed for industrial purposes. The quantity of alcohol so used is estimated at 4,200,000 U. S. gallons. The total amount of industrial alcohol consumed in this country therefore approximates 60,-000,000 U. S. gallons.

The entrance of the United States into the war, and the necessity for the conservation of food materials brought about thereby resulted in the passage on August 10, 1917, of an Act of Congress prohibiting the manufacture of beverage alcohol from foods, fruits, food materials and feeds. The importation of beverage alcohol into the United States is also prohibited. Industrial alcohol is therefore at present alone in the field.

### GOVERNMENT REGULATIONS HAMPER INDUSTRY

The war has brought about no radical changes in the industry of industrial alcohol other than to increase the production for war purposes. The Government rules and regulations surrounding the manufacture, sale, and distribution of alcohol still remains

a source of expense and difficulty to the manufacturer and the consumer. The new revenue laws have still further complicated the sale and distribution of domestic alcohol so that today it is difficult if not impossible to purchase a small quantity of the pure commodity for legitimate household use.

The existing regulations governing the manufacture of industrial alcohol are the outgrowth of the moonshine whiskey days. They were designed to curb the illegal activities of numerous small operators. Time has modified these regulations somewhat, but the producers of industrial alcohol today find themselves still surrounded and hindered in the operation of their plants by a host of antiquated rules. The passage of the recent emergency measure prohibiting the manufacture of alcoholic beverages taken in consideration with the probability that this law will continue in force after the war makes the present an appropriate time for a reconsideration of the rules and regulations which hamper the production of industrial alcohol.

### USES OF ALCOHOL IN THE ARTS AND INDUSTRIES

It is scarcely fitting in these days to go into detail on the subject of the relation of the alcohol industry to the war or the uses of alcohol in warfare, though these are matters of considerable interest. It is believed, however, that a brief review of the uses of alcohol in the arts and industries may be of value at this time when at the Fourth National Exhibition of Chemical Industries each and every chemical industry is passing in review before the public eye.

The uses of alcohol may be more or less arbitrarily classified into five groups as follows:

1. Fuel.
2. Raw Material in Chemical Processes.
3. Solvent.
4. General Utility.
5. Miscellaneous.

#### USE OF ALCOHOL AS A FUEL

Alcohol is used for the production of heat, light and power. Since the combustion of alcohol is smokeless and odorless, it is an excellent fuel for use in small stoves, chafing dishes, cigar lighters and a variety of similar devices.

When alcohol is gasified and burned beneath the familiar Welsbach mantle, a clear while light is produced. Burned in this manner a given volume of alcohol will produce over three and one-half times as many candlepower-hours as the same volume of kerosene burned in a good kerosene lamp.

The use of alcohol for power purposes has never been extensive in the United States due in part to the cheap petroleum products available and in a great measure to the reluctance of the Government to remove the restric-



tions which interfere with the development of the art of manufacture of alcohol, curtail production, and increase the expense of operations. In Europe, on the other hand, alcohol in admixture with other liquid fuels has been very extensively employed as a motor fuel.

#### ALCOHOL AS A RAW MATERIAL IN CHEMICAL PROCESSES

*Oxidizing Processes.* The oxidation of alcohol to acetic acid by air in the presence of an enzyme catalyzer has long been a familiar process. It is only recently, however, that the oxidation of alcohol to aldehyde, and the aldehyde to acetic acid, has been brought about by inorganic catalyzers.

Other commodities which may be mentioned as the products of oxidizing processes are chloral hydrate, chloroform, iodoform and fulminate of mercury.

*Dehydrating Processes.* The dehydration of alcohol gives rise to ether or to ethylene according to the manner in which it is carried out. The dehydration with sulphuric acid under carefully regulated conditions produces ether. The dehydration of alcohol to ethylene with aluminium oxide as contact catalyst is a recent war development of considerable interest.

*Esterification.* The production of such esters as ethyl acetate, ethyl formate, and ethyl chloride has been somewhat stimulated by war conditions. Numerous other esters, including ethyl butyrate, oxalate, benzoate, succinate, and aceto-acetate, are also of commercial importance.

*Ethylation.* Alcohol furnishes the ethyl group for the production of the alkylamines, ethyl and diethyl aniline. It is used also in the ethylation of the phenolic group of para-nitro-phenol in the production of acetphenetidin.

#### ALCOHOL AS A SOLVENT OR LIQUID MEDIUM

Alcohol, next to water, is undoubtedly the most important solvent. A brief consideration of its multitudinous uses bears out this fact.

*Solvent for Gums.* Shellac and spirit varnishes are produced by the dissolving of shellac and other gums in alcohol. The alcoholic solution of shellac serves a variety of purposes and is necessary in the manufacture of felt and straw hats, mirrors, brushes, electric lamps, patterns for the foundry, etc.

*Solvent for Soaps.* On account of the fact that the soaps dissolve in alcohol, this substance is used in the manufacture of transparent soap and certain soluble cutting oils. Alcohol is solidified by means of soap. In this form it is used as a fuel for cooking or heating purposes.

*Solvent for Essential Oils.* Alcohol is used both in the manufacture of essential oils and in the preparation of essences. A few typical examples are essences of vanilla, lemon, wintergreen, rose, jasmine, heliotrope and bay.

*Solvent for Nitrocellulose.* While alcohol alone is not a solvent for nitrocellulose, it is used in large quantities mixed with ether in the manufacture of smokeless powders, and collodion. Collodion is consumed in large quantity in the production of artificial leathers, and in smaller quantities in the manufacture of artificial silk. Small amounts of alcohol are used in the preparation of photographic emulsions and in the making of carbon lamp filaments. The manufacture of pyroxylin plastics calls for the use of a considerable quantity of

alcohol. The fact that alcohol in itself is not a good solvent for nitrocellulose is made the basis of the solidification of alcohol by the production of some form of emulsion or colloid of nitrocellulose in alcohol.

*Solvent for Dyes.* Alcohol is used as a solvent in the manufacture of a great many dyestuffs. It is also useful as a medium for the vending of colors to the trade in the form of solutions or pastes. Alcohol soluble colors are used in the making of confectionery and artificial flowers, and in calico printing.

*Solvents for Drugs and Chemicals.* Alcohol is necessary as a solvent in the processes of preparing a variety of drugs and chemicals. A few of these substances which may be mentioned are aloin, arbutin, baptisin, cimfunin, coumarin, hydrastis, inisin, mandrake, phenolphthalein, phytolaccin, strychnine, tannic acid and viburnin.

*Solvents for Use in the Preparation of Tinctures.* The alcoholic solutions of numerous drugs and chemicals are placed on the market as tinctures. A few typical examples are tinctures of aconite, arnica, cantharides, digitalis, iodine, and nux-vomica.

*Solvent in Crystallization Processes.* A large number of substances are recrystallized from alcohol, among which may be mentioned aconite, beta-naphthol, beta-naphthol benzoate, guaiacol, guaiacol carbonate, monobromated camphor, ortho-toluol sulphamide, phenyl salicylate, and terpin hydrate. In the case of other substances, such as trinitrotoluol (TNT), crystals are sometimes washed with alcohol to remove impurities.

*Alcohol as a Cleaner or Cleanser.* Oil and shellac are removed from metal parts by means of alcohol in the process of manufacture of various articles such as cutlery, jewelry and watches, silverware, bronze and art metal work, and special glassware such as thermometer and barometer tubes.

*Solvent for Oils and Waxes.* Alcohol is used in the manufacture of celery oil, shoe polishes, and paint and varnish removers. It is used in the refining of mineral oils for the production of the highly refined medicinal oils. It is sometimes used in the purification of rubber to dissolve foreign gum and waxes.

*Alcohol as a Diluent or Thinning Solvent.* A number of preparations such as airplane wing dopes, metal lacquers, enamels, polishes, lotions, and linaments contain alcohol as a diluent.

#### ALCOHOL AS A LIQUID OF GENERAL UTILITY

In the hospital, the chemical laboratory and the home, alcohol is a liquid medium of general utility. In the hospital it serves as an antiseptic and as an abluion. In addition to these purposes, it is used extensively in the home as a fuel and cleaner. Its indispensability in the laboratory is too well known to every chemist to need elaboration.

#### MISCELLANEOUS USES OF ALCOHOL

Alcohol finds application for a variety of purposes which are difficult to classify. It serves as a preservative for specimens in biological museums. Many proprietary medicines also contain a certain proportion of alcohol added to preserve other components of the mixture.

The addition of alcohol to the water in automobile radiators, hydraulic jacks and presses in the winter

time prevents freezing. This has proved of extreme importance in the war. Water is frequently scarce near the battlefield, and it is highly desirable to be able to avoid the draining of the water from radiators at night. An economy of gasoline also has been effected through lack of the necessity of keeping the engine running when a car was idle for a short time.

Alcohol is used to remove the carbon from automobile engines or other gas or gasoline engine cylinders. The "carbon" is an accumulation of siliceous dust, carbon and heavy tar and oil. The solvent effect of the alcohol on the oils and tars is responsible for the removal of the carbon.

Alcohol is used as an antiseptic. Solutions of such substances as resorcin or beta-naphthol in alcohol are exceedingly valuable in this connection.

Alcohol serves as a reaction medium in the manufacture of a number of substances among which may be mentioned santonine benzoic acid and sodium benzoate.

The small solubility of certain substances in alcohol is responsible for the use of alcohol in their processes of manufacture. Such substances are inulin and glycerophosphates.

#### CONCLUSION

It has been possible in the foregoing paragraphs only to mention some of the many uses of alcohol in the arts and industries, but this brief enumeration is sufficient to illustrate the ramifications of this substance into manufacture in general. Its importance at present cannot be overestimated. Its future possibilities are limited only by the regulations with which its use is circumscribed.

U. S. Industrial Alcohol Co.,  
New York City.

### Utilizing Waste Sulphite Liquors

In 1906 letters patent were granted to Jacob S. Robeson for a process to neutralize and concentrate *in vacuo* the waste liquors of sulphite pulp mills. The inventor and his associates made the proposition to a pulp mill that was having trouble with stream pollution, to put the offending waste to use and a little test plant was built with a view to producing by this means an adhesive to make sand cores for hollow castings. How much of the offending liquor could thus be disposed of was a question, and it stands to reason that the amount, during the formative period, was not large. In the meantime the proprietary company has developed so that it now has two large evaporating plants which substantially consume and thus dispose of the waste liquor output of two large sulphite mills, one at Au Sable Forks, N. Y., and the other at Covington, Va.

The feature of general interest which we think worthy of emphasis is that in the instances of these two mills, the waste liquor nuisance is said to be practically eliminated. The process, roughly, consists in neutralizing the liquor and evaporating it to a thick syrup or to dryness under reduced pressure. Of course there are stratagems and refinements in the process. The ligneous spruce product is sold under the trade name of glutrin. It is, in substance, the sulphonated lignins neutralized with lime and magnesia, with other bases substituted or the lime removed for special purposes by processes patented and controlled by the company.

As a core binder it did well from the start and its use in this respect has already reached large proportions. But even if all the foundries in the world should use it, a few pulp mills could supply the entire demand. Later research, however, proved that the gum had an unusual affinity for clay and the manufacturers set out to introduce the product as a road binder.

Portland cement with sharp sand in volume 1 to 3 breaks approximately at 200 to 230 lb. Glutrin with sharp sand mixed with 15 per cent of clay shows the same tensile strength in volume of 1 to 25.

Other uses are coming to the fore, but none with the possibilities of road binding except, perhaps, as an adhesive for briquetting. Much less glutrin is needed than pitch for this purpose and in this respect it is promising, owing to its cheapness as well as its effectiveness. Last winter during the coal famine it was found useful to bind coal dust for boiler purposes without going through the process of briquetting. Coal dust, which was all that was obtainable by some landlords, was dumped upon the boiler room floor, glutrin was poured upon it which immediately bound it, and then it was fed wet into the fire boxes of the boilers. Several large buildings were kept warm by this means which otherwise would have been closed by the cold. When glutrin is submitted to the high temperature of the fire under the boilers it burns completely.

Still another use after it has undergone purification is for finishing leather in the tanning industry. It contains 25 per cent of tanning materials, which is significant. This application is also increasing.

The material itself is soluble in water but it can be made practically waterproof. If two pieces of paper are held together by an exceedingly thin film of glutrin, they become impervious to oil and grease, and it is suggested that cartons made of paper with glutrin sandwiched in between the sheets, would make good containers for oily substances.

Again there are indications of its use in the textile industry, although no method of bleaching has thus far been devised.

More important than the introduction of a new technical material is the avoidance of sulphite pulp waste liquor. We continue to talk a great deal about this nuisance but it continues to flow into our most beautiful streams and to kill fish merely as one of its many vices. Evaporated, it has its uses, but not enough. What interests us especially is that some application be discovered for evaporated sulphite waste liquor, whether prepared by this process or any other, so that one of the greatest of all sources of stream pollution may become a thing of the past. If a large, general use for the product could be discovered we should soon see a treating establishment attached to every pulp mill and a source of serious offense turned into an asset. The chemist who solves this problem will probably reap a fortune, but he will also be justly entitled to a medal from Congress, and the day of its accomplishment may not be so far away, either.

Artificial Honey is reported as being prepared in Germany. The hydroxide or other suitable compound of iron is added to sugar during inversion whereby salts of iron are produced with the acid used for inversion and saccharates of iron with the sugar.

# Organic Synthesis and the duPont Company

Evolution and Growth of a Varied Organic Chemical Industry—Introduction of Nitro Explosives Brought About First Advance—American Chemical Manufacturers Must Blaze New Trails and Engage in Thorough Research

By C. L. REESE AND C. M. STINE

**S**YNTHETIC organic chemistry has been a factor of such great importance in the development of the wide variety of the du Pont Company's products that it is difficult to pick out of the finished products marketed by this company any one product in the development of which the organic synthetic chemist has not had a part. Evolution and growth are not necessarily simultaneous processes. The former represents increasing complexity and better adaptation to commercial requirements and is more important than mere growth, consisting of expansion without added differentiation. It is safe to say that the development of the du Pont company has been characterized by both. During the very early years of the life of the company, when its activity consisted almost solely in the manufacture of black powder, no applied organic chemistry was involved, but this situation was altered with the introduction of nitroglycerin and nitrocellulose explosives. The next great advance came with the introduction of the benzol high explosives which led quite naturally into the field of coal-tar products, in general comprehending intermediate and dyes as well as numerous other products in adjacent domains of manufacture, all logically associated with each other.

## STUDY OF SYNTHETIC GLYCERINE.

Dynamite contains as one of its most essential constituents nitroglycerine or similar nitric ethers, together with one or more organic compounds of a similar nature, added for the sake of introducing some special property or properties in the finished product. The manufacture of nitroglycerine itself has meant for this company not merely the nitration of glycerine but also the study of various methods for synthesizing glycerine. Coincident with the study of synthetic glycerine the study of other nitric ethers of very similar properties has been under way for years and has resulted in the synthesis of certain nitrated products, true nitrates—not nitro substitution products—which have served to replace varying quantities of nitroglycerine and at the same time to give the dynamites certain very valuable properties not conferred upon them by the use of nitroglycerine alone.

Then too there is the field covered by the nitro aromatic compounds which are used not only in admixture with nitroglycerine and other nitrated alcohols of similar constitution, but some of which are themselves employed as explosives. The manufacture of nitro compounds derived from benzene, toluene, xylene, phenol, cresol etc., has often involved not merely the study of the action of nitric acid upon these organic compounds but in some cases has involved a study of methods for the manufacture of the compounds them-

selves. Toluol has been produced on a commercial scale by the du Pont company for some years past, and, of course, synthetic phenol and the synthesis of picric acid through chlorbenzol instead of by the nitration of phenol are operations which at once occur to every chemist who may chance to read this article.

It is scarcely necessary to say that such compounds as tetranitromethylaniline, the "tetryl" of commerce, have been manufactured by the du Pont company for some years and that the manufacture was worked out as a going proposition before the great war had started. The nitration of benzol, with the production of mononitrobenzol and from this of aniline, had led to the manufacture of diphenylamine and dimethylaniline.

## EVOLUTION OF NEW EXPLOSIVES

The development of new explosives so necessary to enable the du Pont company to develop its great explosives business has, of course, led to the study of a very wide field of organic compounds which for one reason or another were believed to be worthy of investigation for the sake of determining their possible suitability in this connection. A number of very useful new explosives have been developed and some of these compounds will no doubt prove a fruitful source of interesting investigation when a study is made of their properties other than explosive.

The manufacture of smokeless powder involves a very expert knowledge of the nitration of cellulose and the conduct of various nitrates of cellulose in different solvent media. This business very naturally went hand in hand with the development of such products as lacquers, pyroxylin solutions and leather substitutes. These lines of business, calling for colors, involved either the purchase of dyes, pigments and lakes from outside sources or the manufacture of these products by the company. The company preferred to engage in the manufacture of these products for itself, because of the close relation to its business as a whole as well as because it is one of the largest manufacturers of heavy chemicals in the world.

The preparation of the nitro aromatic compounds already referred to is so closely akin to the preparation of some of the raw materials used in the manufacture of dyes that it was scarcely a step for this company to launch out into a very comprehensive manufacture of intermediates used largely for dyestuffs, as well as in a more limited way for pharmaceuticals. When one enters the wide and fascinating field of the chemistry of dyes and intermediates, the activities of the organic chemist at once become of the first importance. This is so well known that it is scarcely necessary to do more than mention in passing that hundreds of chemists are



engaged in the manufacture of various organic compounds used for explosives and dyes.

#### DIFFICULTIES OF ORGANIC SYNTHESIS

In a surprisingly large number of cases chemical investigation of synthetic processes has resulted in the discovery of improved methods, differing widely from those previously employed. In all cases the study of synthetic methods has resulted in less radical though no less important changes in the methods themselves. Nothing sounds easier than the preparation of some well known organic compound such as diphenylamine. A cursory examination of the literature furnishes a description of various methods of preparing this material, but like all other organic reactions it requires careful control if satisfactory results are to be obtained. It is influenced by conditions which are nowhere mentioned in the literature because they can be ignored in the small scale preparation of the material. Furthermore, the chemical manufacturer who produces this material in large tonnages is not given to publicity in regard to details which determine the success of his plant. Every stage and every detail of preparation must be subjected to the closest scrutiny. Wholesale production of course requires more accurate regulation than does laboratory preparation. When a pound of the material is prepared the occurrence of small amounts of by-products is ignored, except in so far as these by-products and residues merit study because of the light which such a study may throw upon the reaction. But the large scale manufacture may fail entirely because of the accumulative catalytic effect of small amounts of by-products developed in the reaction and adhering to the interior of the apparatus from one run to the next, even though the bulk of the product is removed from the apparatus after each charge.

#### VARIED PROBLEMS ATTACKED BY DU PONT CHEMISTS

Perhaps it would be interesting to enumerate a few of the many and varied problems which the organic chemist has turned his attention to at one time or another in the synthetic laboratories of the du Pont company. The company is manufacturing brushes for "my lady's toilet table." The handles and backs of these brushes call, first of all, for cotton of a particular grade and the purification of this cotton. Next, this specially purified cotton, the properties of which have been studied from every standpoint in so far as the nature of the impurities present in the cotton and the methods followed in their removal may affect the desired properties of the finished article, is subjected to the action of a mixture of nitric and sulphuric acid, and the nitric ether of cellulose thus obtained is ready for purification. Here again the most thorough-going and far-reaching study is made of the effect of various impurities in the nitrocellulose and the effect of the different methods used for removing these impurities upon the physical and chemical properties of the finished toilet articles. Perhaps the finished toilet article instead of being white or cream colored is to be tinted or is to be inlaid with some colored design. It is necessary to study the various coloring matters available, with a view to selecting such dyes as may be soluble in the solvents employed in working up the nitrated cellulose, and at the same time dyes which will show

the necessary fastness to light and the necessary stability so far as the action of the colloid or of the air is concerned. Now the brush is complete save for the insertion of the bristles. Here a new problem presents itself—a shortage of the natural bristles which used to be imported before the war. It becomes necessary to attempt to prepare artificial bristles. At first glance this seems a simple proposition, but a naturally produced bristle has many unique properties and it becomes necessary to make a most painstaking investigation of the nature of these properties which give the natural bristle its character in order that in the duplication of this bristle it may be possible to decide when a synthetic article of the proper degree of excellence has been prepared.

#### PRODUCTION OF ARTIFICIAL LEATHER.

Closely related with the production of articles of "pyralin" is the production of the class of goods known as artificial leather or fabrikoid. The coating of suitable fabrics of various weaves and tints with pyroxylin solutions and the subsequent fabrication of these coated goods to a leather-like finish has involved the attention of many chemists, and many interesting discoveries have been made in this connection. The manufacture of fabrikoid well illustrates the variety of chemical processes and products which may be involved in the fabrication of single class of goods. Suitable purified cotton, acids, alkalies, solvents, oils, dyes in wide variety of shade and chemical properties, pigments, etc, enter into the manufacture of artificial leather.

It is worth pointing out in this connection that the field of the organic chemist is by no means merely the imitation of nature's products, but oftener than not the problem involved is the actual building up in the chemical laboratory of the identical product which nature herself has cunningly synthesized in the organism of the plant or animal, as the case may be.

#### SYNTHETIC INDIGO ILLUSTRATES PROBLEM OF LARGE-SCALE PRODUCTION

The manufacture of indigo well illustrates the nature of certain problems which arise if the chemical manufacturer attempts to produce on a large scale even such a product as this which has been produced for some years on a large scale abroad. If the chemical turns to the literature he finds many methods for the preparation of this material, but it is a question not merely of the selection of a method which will produce indigo but of the selection of that method which will best produce indigo of the highest quality and in the most economical way, from certain raw materials which are available because of the du Pont company's activities along other lines. Having selected the method which is to be followed, the next question is the design of the most suitable apparatus for carrying out this method on a very large scale. Without going into wearisome detail, it suffices to say that all of these phases of the problem have been studied and successfully solved and an indigo produced which is much purer than that which is obtained by the extraction of this dye-stuff from its naturally occurring sources.

The embarkation of this company upon the great field of related industries comprehended under the caption "duPont American Industries" will no doubt mean

a wonderful stride forward for the American chemical industry. The logical course is to build an industry which is not merely concerned with chemical products in the narrower sense but with all the logically related forms of the industry. As in the past, success in organic synthesis as a commercial asset can only come to mean what it should if it is properly associated with evolution of the whole industrial organism of which it is a part. We are confident that new processes or distinct improvements over foreign methods of manufacture will characterize the activities of this concern. This is logically to be expected because the chemical manufacturers in the United States start with a clean slate, unhampered by tradition, unencumbered by equipment which may have grown more or less obsolete but which it would be too expensive to abandon. It is necessary above all things that the American manufacturer shall not merely attempt to follow the well beaten paths, but that his activities be controlled by a thorough and painstaking application to his manufacturing problems of the results from the laboratory of the thoroughly trained and skillful synthetic organic chemist.

Wilmington, Del.

### Prices of Sulphuric and Nitric Acids

The War Industries Board announced on September 26 that, subject to the President's approval, the following maximum prices were agreed upon at a meeting between manufacturers of sulphuric and nitric acids and the price fixing committee. These prices are to remain in effect for the remainder of the year:

|                      |             |          |
|----------------------|-------------|----------|
| Sulphuric Acid ..... | 60 deg. Bé  | 2000 lb. |
| .....                | 66 deg. Bé  | \$16     |
| .....                | 20 per cent | \$25     |
| Oleum .....          |             | 28       |

All acids below 66 deg. Bé. are to be evaluated on a \$16 basis and above 66 deg. Bé., on a \$25 basis. One-half of one per cent additional charges are to be made for carload lots of carboys, and three-fourths per cent for less quantities. One-quarter of one per cent will be charged for steel drums.

|                   |            |          |
|-------------------|------------|----------|
| Nitric Acid ..... | 42 deg. Bé | 2000 lb. |
|                   |            | \$170.00 |

One-fourth of one per cent extra charges are made for drums. There shall be no extra fee for mixing charges of mixed nitrating acids, the prices of which are figured on the acid contents.

### Two Great Drives, One of Them Here

Two great drives are to release the world from the hardships of war and preserve mankind from the horrors of autocratic rule. One is along the Western Front in France, Flanders and Lorraine; the other is in the United States.

American soldiers are bearing a brave and splendid part in the military drive "Over There." The American people over here must work as well for the success of the Fourth Liberty Loan drive.

Upon the success of the loan depends the maintenance of the striking force of our troops.

It may be hard for many of us to spare money at this time, even though it is to be returned to us with interest; but it would be still harder for us to think of having failed to do our part if the loan should fail.

## Manufacture of Glycols

BY HAROLD HIBBERT

Director Research and Technical Division,  
Ralph L. Fuller & Co., Inc.

IN a preceding article on "Industrial Developments Relating to the Manufacture of Acetic Acid and Acetone," attention was drawn to the scarcity of acetone occasioned by the increased production of cordite, and of the steps taken to meet this deficiency. Regarding the other two constituents of this explosive, namely nitrocellulose and nitroglycerine, thanks to our abundant natural resources little or no difficulty was experienced in increasing the production of nitrocellulose, but the amount of cordite capable of being produced at the present time is limited by the amount of nitroglycerine available.

As is well known, nitroglycerine is obtained by treating glycerine with a mixture of nitric and sulphuric acids. The glycerine itself is obtained by heating vegetable oils, such as palm oil, cottonseed oil, etc., on the one hand, or animal fats on the other, with caustic alkalis or other saponifying agents producing in this way glycerine and soap. Animal fats form an indispensable, staple article of diet and the same remark now applies to vegetable oils, since from these, by the so-called process of hydrogenation (consisting in treating them with hydrogen), these bodies are converted into butter substitutes and so serve to replace animal butter and animal fats.

It thus becomes an economic problem as to how far the manufacture of glycerine may be permitted without interfering with the use of raw materials for domestic consumption. An idea of the amount of glycerine used in this country prior to the war, may be obtained when it is stated that some 20,000 tons of this material was employed annually in the manufacture of nitroglycerine, while another 7000 tons was used in the manufacture of tobacco. The other uses to which glycerine was put amounted to probably around 3000 tons, so that the total annual consumption in this country prior to the war did not fall far short of sixty million pounds.

Numerous attempts to produce glycerine synthetically from other cheap available raw materials such as sugar, petroleum, etc., have been made, but so far without success. It is a well known fact that in the fermentation of wine, a considerable amount of glycerine is formed from the sugars present, but all attempts to identify the organism and to imitate the process commercially, have so far proved failures. As far as can be judged, there would seem to be comparatively little outlook at present for a successful commercial synthesis of glycerine from known available materials. At the same time, it is not possible to increase the supply of glycerine without in turn diminishing the supply of foodstuffs.

During the last six or seven years the writer has devoted a considerable amount of time to experimenting on this subject, and now believes that in a certain class of products known as glycols, which are closely related on the one hand to ordinary alcohol, and on the other to glycerine, a solution of this problem has been found.

If alcohol is passed over certain contact materials, such for instance as oxide of aluminium, at an elevated temperature, it undergoes a chemical decomposition with the formation of steam and a combustible gas known



as ethylene. This gas is very reactive and combines readily with chlorine forming a product known as "Dutch Liquid," or to give it its chemical name, dichloroethane. The first name was given to the compound due to the fact that it was first discovered by some Dutch chemists in 1795.

When this dichloroethane is heated with water and alkaline carbonates in a closed vessel, a chemical decom-

position takes place resulting in the formation of common salt and a chemical product known as ethylene glycol.

This product can also be obtained by cracking petroleum by passing the vapors through an iron tube heated to about 650 deg. C., mixing the gases thus obtained with chlorine, and after purifying the product so obtained by distillation, subjecting the distillates to the action of alkaline carbonates in a closed vessel. By such a process it is much more difficult to obtain a pure chemical product, but the mixture of glycols thus prepared possesses many valuable properties.

The products so prepared are liquids of a somewhat less viscous character than glycerine, and possess the power of attracting and retaining moisture. In addition they also yield valuable explosives when treated with a mixture of nitric and sulphuric acids. Some of these were tested in Germany prior to the war and were reported on very favorably by certain large explosive manufacturers. While nitroglycerine possesses many advantages over other explosives, it also has several serious drawbacks. One of these is the fact that while it is a liquid at room temperature, it nevertheless freezes during cold weather and its use in this condition is attended with many difficulties and danger. Although many attempts have been made to overcome this, it cannot be said that the matter has, up to the present time, been satisfactorily solved.

This is due to the peculiar, inherent properties possessed by the frozen material. It was proved some years ago in experiments carried out by the writer that when

freshly prepared nitroglycerine explosives are exposed to a low temperature, they freeze, and in this condition the material represents an unstable product, since under the influence of small physical changes it undergoes instant transformation, while in the solid state into a second totally different crystalline modification, with evolution of a considerable amount of heat.<sup>2</sup> The physical factors involved in such a change may be visualized in a very crude manner by comparing them with the stresses and strains necessary, for instance, to change the contour of, say a rectangular cardboard box instantly into one of more complex form, *e. g.*, hexagonal shape.

In Figs. 1 and 2, 3 and 4, are shown actual photomicrographs of the two solid form of nitroglycerine crystals. Figs. 1 and 2 illustrate the unstable, labile form, while 3 and 4 represent the second or stable modification. Bearing in mind the illustration just quoted of the "cardboard box," it can readily be imagined that when a sensitive product, such as nitroglycerine represents, is transformed instantly from one solid crystalline structure into a second, totally different crystalline form, there must be considerable molecular stresses and strains produced, so that at this particular moment the product is super-sensitive to impact and other physical factors. It is believed that this explanation probably furnishes a solution of the numerous unexplained explosions which have taken place in handling nitroglycerine explosives.

In the case of the nitroglycerols, these freeze only at temperatures much lower than in the case of nitroglycerine and as there is no possibility of the formation of an intermediate, unstable, crystalline solid it follows that such explosives are naturally much less dangerous to handle and may therefore be expected to prove of

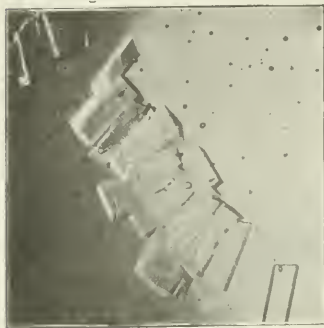


Fig. 1.  
NITROGLYCERINE IN UNSTABLE, MORE SENSITIVE FORM

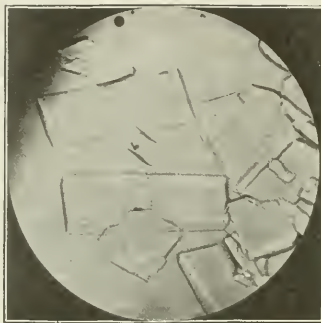


Fig. 2.

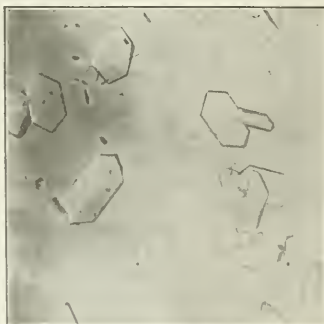


Fig. 3.  
NITROGLYCERINE IN STABLE, LESS SENSITIVE FORM



Fig. 4.

especial value for mining and blasting operations, carried out at low temperatures. It is, in fact, this "safety first" feature which points to the possibility

<sup>2</sup>Zeltgesamte Schiess u. Sprengstoffwesen, Vol. IX, pp. 83-126, and 273, 1914.



of the nitroglycol displacing in future the less satisfactory nitroglycerine explosives.

Furthermore, as regards its use as a constituent of cordite, it is necessary, as stated in the writer's previous communication, in order to bring about an intimate compounding of it with the nitrocellulose, to employ a solvent, which in this case is acetone. This necessitates considerable care and expense in manufacturing, as the value of the explosive is naturally dependent on the absence in the finished product of all traces of the solvent.

We are informed by Mr. Arthur Hough, formerly of the Canadian Explosives, Limited, that extensive experiments carried out by him with nitroglycols on the semi-industrial and industrial scale show that when compounded with nitrocellulose (no solvent being necessary), a valuable new type of explosive is obtained, possessing characteristic properties which indicate that it should be capable of finding a wide outlet both as a war material and for peaceful purposes. With regard to cordite, it is a well known fact that due to the high local temperature produced in the ignition of the charge in big naval or coast defense guns, considerable erosion is produced in the barrel, so that the life of such a gun is limited. This erosive action, will, it is considered be found to be much less pronounced with explosives derived from nitroglycols than from nitroglycerine.

Another new type of explosive, in addition to those described above, has been discovered by the writer. It has been found that sugar is readily dissolved on warming with the glycol and that if such a solution is then treated with a mixture of nitric and sulphuric acids, not only is the glycol itself converted into an explosive body, but the sugar also yields a nitrated product and the combination of the two thus formed is found to possess many valuable properties not associated with any present known types of explosive. There would seem to be solid ground for the belief that such a product should find an extensive application in various branches of the industry, such as mining, blasting, excavating, etc. In view of the fact that one of the principal constituents, namely, sugar is a material available in practically unlimited quantity and at a low cost, it is anticipated that the cost of production of these new products will be materially lower than that of similar bodies derived from nitroglycerine, thus insuring them a very wide outlet.

The glycols themselves have been found to possess many other valuable properties, serving to indicate that they should find a wide application in the field of industry and commerce, so it may be anticipated that in the future the use of glycols will largely displace that of glycerine.

Thus for instance, with regard to the use of glycerine for moistening tobacco, it is known that the combustion of glycerine gives rise to the formation of a poisonous product known chemically as acrolein, and it is assumed that it is the inhalation of this product during smoking that produces in the case of persons susceptible toward such bodies, various types of disorder in the mouth and throat. The chemical composition of the glycols is such that it is impossible for acrolein to be produced when employed for such purposes.

The glycols possess, if anything, a superior attractive power toward water, so that their moisture-retain-

ing properties are even more pronounced than in the case of glycerine.

It is this so-called hygroscopic property (that is, the ability to absorb and retain water) that would seem to make glycols such valuable products for use in the pharmaceutical and allied industries, as for instance in the manufacture of salves, ointments, dressings, etc.

It is also confidently anticipated that the glycols will, on account of their much lower volatility and their affinity for water, prove capable of being used with success to replace alcohol in automobile radiators in order to prevent the water from freezing.

The manufacture of glycols and their industrial applications is a subject which, as stated above, has occupied the writer's attention for a considerable number of years, and due to the fortunate patent protection already available, it is confidently anticipated that rapid strides will now be made in the development of this industry.

The Government has undertaken to investigate the properties of these materials for war purposes, having had the free use of the patents in connection with the same placed at its disposal by the writer for the duration of the war.

There are already in existence certain large factories which are capable of providing raw materials for these products on an immense scale after the conclusion of peace and there is no doubt that with the development of this field a big advance in the true conservation of foodstuffs will have been attained.

New York City.

### Bauxite Deposits in Guiana

Sir Walter Egerton, in his address before the Royal Society of Arts, stated that in 1897 and again in 1910 Professor Harrison reported that extensive deposits of high grade bauxite were located in British Guiana. This discovery was not fully appreciated until five years ago, when the Northern Aluminium Company of America applied for leases of areas containing such deposits. The British Government stipulated that any company working this bauxite must be under its control. After long negotiation, an American company was formed to meet these requirements, and the first cargoes of bauxite were but recently mined and shipped from the colony.

This company has acquired large areas of land from private owners and leases of considerable extent of crown land in the vicinity of Wismar, at the head of navigation of the Demerara River, near the terminus of the little railway connecting the Demerara and Essequibo rivers. Ships with less than 16-foot draft can reach the mines 60 miles above Georgetown.

The bauxite deposits have recently been traced almost from the Venezuelan boundary across the colony to the border of Dutch Guiana. Further deposits have been located in Dutch and French Guiana and it is now thought that this northern strip of South America contains the most extensive deposits of aluminium ore in the world accessible to ocean transportation. The geological formation of bauxite is similar to our secondary fall-line clays, being deposited at the pre-coastal line.

In the United States pockets of bauxite are being worked in Alabama, Georgia and Arkansas, but the shallow depth of the usual bauxite formations makes the Guiana deposits extremely important.

# Micro-Organisms in Plant Chemistry and Nitrogen Fixation

## An Account of the Development and Application of Micro-Organisms Useful to Plant Growth— Fixation of Nitrogen in the Soil

By ELLWOOD HENDRICK

A FEW miles to the west of Hackettstown, N. J., there are some three or four thousand acres of meadow-peat or muck which was formerly covered by a swamp. Underlying it is usually a thin layer of sand which in turn rests upon blue clay. The depth of the greatest part of the muck is from four to six feet, although in places it is but 18 inches; occasionally, it goes down as far as twelve or fifteen feet. Where it extends below the water table there is usually found a layer of fibrous peat above the sand, but there is not much fibrous peat in this district, which is known as Great Meadows or Bog Egypt.

The muck is, in effect, humus, and its use is for fertilizer. But before we begin to consider the technical generalities which follow, let us bear in mind that humus is partly decayed organic matter; that it is the decayed remains of former generations of plant and animal life, on its way to become coal, and beyond the peat stage. Its value is influenced by the kind of organic matter from which it originates, and the state of its decay. Much of its value is due to its nitrogen content, and in this respect, if its origin were cellulose, it would be nil; if it were clover it would be considerable and if derived from the decayed carcasses of animals, it would be higher still. Indeed, the index of its nitrogen value is its pre-geologic history.

But apart from this, humus has other qualities which cause it to function in the support of plant life. It acts as a flocculent in clay and as a binder in sand which might offer at the start a pretty thesis in colloid chemistry. It retains moisture like a sponge, which is another good subject for original work. It supplies, according to its content, nitrogen, phosphorus, potash, lime, iron, manganese etc. for the nourishment of plants, and it is the natural habitat and food of beneficial soil micro-organisms.

### NEUTRALIZING VALUE OF LIME

The New Jersey deposit has the advantage of constituting the drainage area of the surrounding limestone hills whereby enough carbonate of lime is brought down almost to neutralize the humic acids. Still another advantage is that 30 years ago the swamp was completely drained and then practically abandoned. There was lacking the proper understanding of the value of the humus and the development of engineering as well as chemical and biological methods of treatment which later study has supplied. The great value of this preliminary draining in increasing the bacterial life will shortly appear.

For the past twelve years Mr. John N. Hoff of New York and his associates have been engaged in the development of the industry in New Jersey, and later they

have extended their activities to certain other rich deposits in Florida. While the undertaking is to be classed as a fertilizer proposition, it differs materially from fertilizer manufacture and materials as generally understood in chemical engineering.

We often hear fertilizer discussed as though it had to do with abstract problems in chemistry. We know of no other subject to which the popular mind has attributed more than its rightful share of this science. We do not mean to say that the chemistry of fertilizers has been adequately studied; on the contrary, it seems as though, to mention but one of many features, that the great field of protective colloids in the soil holds all sorts of treasures that have not yet been uncovered.



THE DIGGER AT WORK

What has often been forgotten is that agriculture is a profession within the domain of plant physiology rather than of chemistry. In what follows we shall observe that a balanced conception of fertilizers has ruled and that its biological aspect has received its proportionate attention.

### MICRO-ORGANISMS REQUIRE FREE OXYGEN

Operations are carried on under a corporation known as the Alphano Humus Co. and research is prosecuted in various directions under the auspices of that company. We are informed that there are promising indications that it may become possible by simple treatment to bring the humus into a condition whereby the solubility of its nitrogenous bodies may be under almost complete control. The value of such an achievement needs no comment.

The micro-organisms which are most useful to plant life in the soil are of an aerobic nature; that is, they require free oxygen for their development and growth. They do not thrive under water. Therefore the first step in the development of such bogs is to drain. Here we



may note the value of the operations at Great Meadows thirty years ago, because the zymotic growth begins immediately after the water has been removed. Here also we may note again the value of the surrounding hills, for whenever humus is found to be acid it must be limed. As the bacterial life proceeds, some of the carbon in the organic matter goes off as  $\text{CO}_2$ , while under the action of the nitrogen fixers the nitrogen con-



TRANSPORTING HUMUS FROM FIELD TO WORKS

tent is increased. It is interesting to note that there are nitrifying organisms (actinomycetes) which are closely allied to yeast plants as well as moulds or fungi which seem to be especially active, besides the bacteria proper.

The next step is to grow crops under which the condition of the humus improves through aëration, while the crops themselves are record breakers. Onions may be raised to the extent of 1000 bushels to the acre, while 800 bushels may be obtained with ease. Cabbage grows with great vigor and heads up as solid as a German professor when he discusses the cause of the war. Potatoes produce 400 to 500 bushels to the acre while lettuce runs over 1000 boxes to the same area. A box contains 24 large, solid heads. Celery is equally prolific; there are usually over 200 crates to the acre and it takes 120 such crates to fill an ordinary freight car. If all of this district were under diligent cultivation it would effect a material contribution to the metropolitan food supply. Cultivation also eliminates the seeds of weeds.

#### MINING THE HUMUS

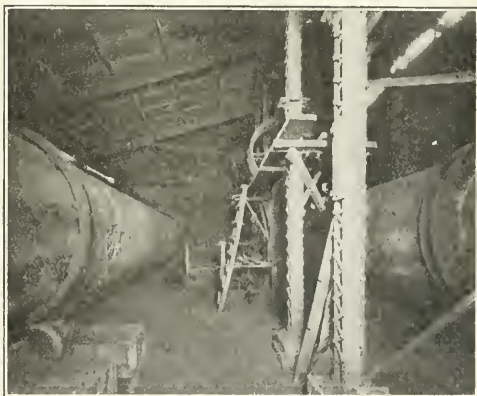
When it is determined to mine the humus after cropping, a temporary narrow gage railroad track is laid upon the surface. Then parallel with the track, at a distance of about 150 feet from it, operations are begun with a specially constructed digger, driven by electricity, with a trailing wire. This proceeds very slowly, digging a trench to any depth up to six feet by means of buckets, scattering the humus upon the surface between the trench and the railroad. Surface water is removed from the trenches by rotary pumps. The surface is then harrowed several times each with tractor-drawn harrows of three types, viz., disc, acme (or corkscrew) and spike-tooth, to a depth of two to three inches. After drying in the sun for a day or more it is pushed to a

depth of about two inches over to the railroad track by means of an electrically-driven scraper. We then have a windrow or ridge of sun-dried humus ready for loading. The water content has been reduced from around 80 per cent to between 50 and 60 per cent. A third electrically-driven apparatus loads it upon dump cars on the track. The digger, scraper and loader are all specially designed and built for the purpose and they do their work exceedingly well. The railway carries it to the factory where the humus is piled in great heaps of 25,000 to 50,000 tons. These are, in effect, composting heaps, and the longer they remain the richer the zymotic life of the humus grows. The moisture content does not increase.

#### MECHANICAL PREPARATION BY DRYING AND SCREENING

Three separate products are made from this material. The simplest and cheapest is called "humus tankage." To make it, the humus is run through a rotary, direct-heat dryer, revolving six times a minute. It requires about fifteen minutes for the humus to run through. A very simple test provides against over-heating: as soon as it burns, the smell of ammonia is noticeable and the fires are slowed down. From the dryer the humus is passed through screens and the tailings are ground and then also screened, so that the finished product is in a pulverulent condition. The process is carried on under laboratory control. The humus now contains 10 per cent water, 3.25 to 3.50 per cent  $\text{NH}_3$ , 0.3 per cent  $\text{K}_2\text{O}$ , 0.4 per cent  $\text{P}_2\text{O}_5$ , and about 8 per cent lime, with 80 per cent and over of organic matter. The bacterial count is light, owing to the high temperature drying.

This is, itself, a low-grade nitrogen fertilizer, but its particular use is as a fertilizer ingredient. In this



ROTARY DRYERS

connection it is better than dried blood because it absorbs water more readily and keeps the mineral content in a more pulverized condition. The advantage of having some of the nitrogen in a mixed fertilizer in organic form is well known. If its fixed nitrogen is made up of ammonium sulphate, ammonium nitrate and nitrogen organic matter, the solubility is more gradual and the loss through seepage is less than if all the nitrogenous is in an inorganic form. If used separately, the effective fertilizer value of nitrogen humus is claimed to be about three times that of  $\text{NaNO}_3$ .



The second product is called "prepared humus" and is made from the same basic material, but run through the dryers with a lighter fire so that the water content is brought down to 18 to 25 per cent. This is as low as it can be economically obtained without destroying



HEAPS OF HUMUS AT LEFT AND STABLE MANURE AT RIGHT HAVING THE SAME FERTILIZER VALUE

the micro-organisms. Balancing minerals are added to this, chiefly of a potassic and phosphatic nature, as well as pure cultures of nitrifying organisms, so that the finished, mixed product contains about 3 per cent of  $\text{NH}_4$ , 0.5 to 1.25 per cent of  $\text{P}_2\text{O}_5$ , and one-half to one per cent of  $\text{K}_2\text{O}$ . The organic matter is 75 to 80 per cent. The bacterial count is from 50,000,000 to 300,000,000 per gram, which increases with time. A bacterial count of 18,000,000 per gram in soil is remarkably high. This is a balanced fertilizer of unusual bacterial activity. It is employed by market gardeners and landscape architects rather than by farmers. The manufacturers claim for it a fertilizer value of several times its weight in stable manure and that one ton represents



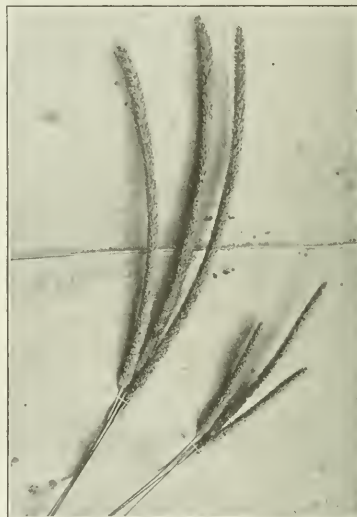
ONIONS AS THEY GROW AT GREAT MEADOWS

the value of many acres of clover turned under and decayed to restore worn-out soil.

#### ORGANIC FIXATION OF FREE NITROGEN

The third product is called "inoculant" and is prepared by adding first to sun-dried humus various chemicals which render it more available for the growth of bacteria, much as bakers use yeast food in their dough. The inoculant contains ammonifying organisms which decompose the humus and render it more soluble, azotobacter, which live in all soils on the organic matter found in them, and radicicola, which cause the nodules to grow on the roots of leguminosae. Without radicicola

leguminous plants do not form nodules and without nodules they extract only fixed nitrogen from the soil and do not fix free nitrogen. In the described form the inoculant is composted for one year during which time the micro-organisms increase. Then there are added pure cultures of some 28 leguminous bacteria. Of these there are seven main types, of which some will answer for several species while others will answer for only one. Thus that which will inoculate alfalfa will also inoculate sweet clover, and the vetch bacteria will also inoculate garden peas. On the other hand, that which is good for soy beans is not active with anything else, and the same may be said of the bacteria for cow peas.



TIMOTHY WITH AND WITHOUT ENCOURAGEMENT FROM PREPARED HUMUS

To make sure to cover the largest variety of leguminosae, all 28 are put in. Finally there are added five different strains of azotobacter that are valuable in any soil that contains a good supply of organic matter. All of these micro-organisms live, so to speak, on good terms with each other; indeed, each appears to thrive better in the presence of the others.

Here we lose interest in standardized chemical analyses of the product. Two pounds of it are enough to inoculate an acre of land. It is in growing use by farmers, for leguminous crops. A favorite method is to mix one-half of the inoculant needed thoroughly with the seed, before sowing, and to scatter the remainder mixed with dry earth over the soil. Another method is to use it in composting manure heaps. One pound of inoculant, if six months time is allowed for composting, is enough to inoculate one ton of stable manure. The desired organisms do not generate spontaneously in manure; and the lack of them is often the cause of a farmer's bad luck despite heavy fertilizing. The proper use of inoculant seems to point the way toward biological as well as chemical control of fertilizer, which has long been greatly desired. It will be a great day for agriculture when every farmer works with a microscope.

## War Problems of the Rubber Industry

**How United States Manufacturers Met the Rubber Shortage and Devised Substitutes for Colors and Fillers—Real Triumphs in Making Gas Masks and Balloons—Making of Pleasure Vehicle Tires May be Discontinued**

By ANDREW H. KING

IN COMMON with all other industries, rubber has been called upon to bear additional burdens and to accept new responsibilities because of the war. Undoubtedly the most serious question which is confronting American manufacturers today is the shortage of rubber. When the embargo was first applied by the War Trade Board, factories were allowed seven-sixteenths of their last year's consumption. Ocean tonnage is now in even greater demand than it was a few months ago. As a consequence the ration has been cut to six-sixteenths, or three-eighths of last year's consumption. To meet this situation the manufacturers have agreed to restrict the production of pneumatic tires, tubes, tires for horse-drawn vehicles and non-essentials such as bathing caps, rubber bands, toy balloons, advertising specialties etc. The curtailment is now proposed only for the months of August and September, but it is not unlikely that even more stringent restrictions will be applied and that in the near future the manufacture of tires for pleasure vehicles will be entirely discontinued for the period of the war. The rubber industry is getting over to a war basis. The manufacture of everything that will help win is going steadily forward. Non-essentials are even now in growing disrepute.

Apparently the government has placed every privately owned car, whether Packard or Ford, in the non-essential class. In many instances this is wrong, since the machines furnish transportation to many suburbanites who are thus enabled to live in the country and work in the cities. The curtailment of tires will, no doubt, effect quite a saving in gasoline, but it seems that this desideratum might have been effected easier by licensing owners of cars and restricting their machines to purely business or war-industry purposes.

### IMPORTANCE OF TRUCK SERVICE

Truck tires are now in great demand. The value of motor-truck service can hardly be estimated, but it is enough to say that 400,000 new trucks will be placed in operation this year. In every war, transportation has always been the knotty problem. If we had had to depend on the railroads we would not have a single soldier in France today. Between all important cities trains of motor trucks now go back and forth. The railroads put the canals out of business because of superior speed. Truck trains now carry material from Detroit to New York much quicker than the express companies. Whenever anything must be had in a hurry they send a truck after it. Today the trucks are the red blood corpuscles of our defense. Every new machine must have at least four new tires, so on the basis of the above estimate 1,600,000 solid

tires must be provided this year. This figure is low, because many machines are equipped with duals on the rear wheels, making six tires to a truck. These truck tires take a lot of rubber. Of course compounds vary but a 34 x 6-in. solid tire will contain from 20 to 30 pounds of good rubber. It is readily apparent that the increase in solid tire production will more than offset the pneumatic tire curtailment, and it is not improbable that in another year the consumption of crude rubber will exceed the 160,000 tons used in 1917. Many of the new trucks will be owned by the Government but business men are buying them in large numbers. The problem the rubber men must solve is where to get rubber enough to keep the trucks moving. Without tires transportation would be in a hopeless muddle.

There is now no such shortage of raw materials as was in evidence at the beginning of the world war in 1914. Practically all compounding ingredients are produced in large quantities in this country. One of the first to show the effects of war demands was zinc oxide. In 1915-16 it advanced to about double its old price. About this time gas black was introduced. By 1916 there were at least six standard grades of black tires offered. Since then gas black has been recognized as an excellent substitute for zinc oxide and the resulting tire is admitted to be superior in many ways to the old. It has been estimated that fully 30,000,000 pounds of gas black will be used by the rubber industry this year.

### SUBSTITUTES FOR COMPOUNDING INGREDIENTS

Another ingredient which caused us no little worry in 1915 was antimony sulphide, which was formerly imported extensively from England and used in rather large quantities in the manufacture of inner tubes. The grades chiefly employed were known as golden and crimson antimonies. They consisted of mixtures of antimony tri- and penta-sulphides in varying proportions, and carried an added free sulphur content approximating 15 per cent. Certain varieties also carried calcium sulphate which was thought to intensify the color. With the beginning of the war, England found need for all the antimony she could produce, so our tube manufacturers had to do without. Many of them developed tubes equally as good as their old products without the least trace of antimony in them. Because of the high regard in which the public held red inner tubes, certain manufacturers colored their products with iron oxide but the larger number sold their tubes on their own merits. By the close of 1915 American-made antimonies began to come on the market and now the old-fashioned tube maker can make just as good a tube as he ever did, but with American antimony,

However, certain other manufacturers liked their new tubes so well that they have not changed them back to the old formulas. The reason for this is not due to any lack of quality in American antimony, but because of some very desirable properties of the new tubes.

Pigments at first gave us considerable trouble. The colors used by the rubber manufacturers are very simple, notably white, black, red, yellow, green, blue, and orange. The white is secured by zinc oxide, lithophone, whiting etc. Because of the extensive use of lithophone in both paints and this industry, a number of new plants for its manufacture have been erected. At the present writing the home demand has been satisfied. Black is the easiest color obtained; the various grades of lamp and gas black are all made at home. The chief red pigment is red iron oxide. It is extensively employed in coloring all sorts of articles. In the old days vermilion, mercury sulphide, was thought to be much better, but it is now recognized as being too expensive and much too heavy. Very pretty shades were obtained by its use, but because of its high specific gravity and the excellence of iron oxide colors it will never be extensively employed again. The yellows and oranges are produced by the different chrome pigments and ochres. At one time considerable arsenic yellow (sulphide) was employed. All these were obtainable in this country. The greens used are the well-known chrome products. There was at first some difficulty in obtaining ultramarine blue but American manufacturers are now producing a satisfactory color. Pigments for the rubber industry must be quite stable and must bear heating with sulphur without any darkening in color or decomposition.

#### DOMESTIC FILLERS AND ACCELERATORS

Barytes is one of the commonest fillers. It is extensively employed in mechanical goods and in certain high-class compounds, notably frictions. With the beginning of the war we found ourselves cut off from foreign sources of supply. Later the Southern deposits were opened and now there are three grades of domestic products obtainable: (1) An off-color barytes carrying iron which has been finely ground. It is applicable in dark colored products. (2) A white product (ground) from which the iron has been removed by acids. (3) A very fine white precipitated barytes which is much better than the ground product.

Both precipitated barium sulphate and carbonate have been proposed as zinc oxide substitutes. While not as satisfactory as zinc oxide their use in limited amounts is becoming quite general.

The great development in organic accelerators has come about since 1914, so the German dye industries got no chance to control it. At first each company made its own accelerators but now the American dye factories are producing thiocarbonyl, para-phenylenediamine, hexamethylene-tetramine etc. which are quite satisfactory.

There have been some rumors of a shortage in sulphur, but it is believed that with a little conservation our Louisiana supply will be found quite ample. Should the rubber industry ever be put to it for sulphur we may expect some stormy days ahead.

Instances could be multiplied without number where American ingenuity has found the loophole from a try-

ing situation by either finding a way to do without a certain material or by producing it at home. The real triumphs of our rubber manufacturers are not that they kept running full blast in the face of unusual conditions but that when called upon for war products they responded so well. I refer particularly to gas masks. They were expected to furnish all kinds of tires, tubes, and mechanicals as a matter of course, but the gas mask was something entirely new. The gases met with are exceedingly reactive. That rubber was compounded to resist them was indeed a victory. True, the British and French were pioneers, but the American masks are very good if not better than the best our Allies have so far produced. Without gas masks for our soldiers, the Huns would have won this war long ago.

The manufacture of kite and dirigible balloons is another instance. Hydrogen diffuses very readily through ordinary proofed fabrics. It has been necessary to develop new combinations which give maximum resistance. In this field the English and Scottish firms long held full sway. Thanks to their help, American blimps are now equal to those of our Allies.

The rubber industry is mobilized. Everything possible to aid in winning the war will be carried forward. Drags and unnecessaries may expect to be ditched.

#### Soap Substitutes in Germany

In view of the shortage of fats, attention in Germany is being directed to the use of the natural soap substitutes occurring in certain plants. Thus, the soapwort (*Saponaria officinalis*) contains large quantities of saponin, a fact which can easily be demonstrated by rubbing the leaves or stem in water when a thick soap lather is readily produced. The root is the part of the plant richest in saponin. After digging up, it is thoroughly washed, dried and reduced to as fine a powder as possible. It can then be used, both alone for the hands, and in conjunction with soda for linen. The substance is an excellent detergent with good lathering properties.

A number of other plants can be used for the same purpose, although their saponin content is lower than that of the soapwort. All these are common plants, easily gathered, and in many cases can entirely supplant the costly substance, soap.—(*Seifenfabrikant*.)

#### Utilization of Reclaimed Rubber in Germany

At the twenty-fourth general meeting of the German Bunsen Society (for applied physical chemistry) held in Berlin on April 8 to 10, 1918, Prof. M. Le Blanc of Leipzig exhibited specimens of a reclaimed rubber named "Agatit," the process of manufacture of which was worked out by him in collaboration with Dr. Lüttke. The material is being made in large quantities both in the solid form and as a fine emulsion. Its use is specified by the Reichsmarineamt in place of natural rubber for the preparation of sheeting and high-pressure packing material such as is used in submarine construction. It is also used as a substitute for leather; it can be nailed or sewn, it withstands sterilisation well, and the difficulty of rapid ageing has been overcome. Such articles as operating gloves (2mk. 50), finger stalls, and teats (0.25 mk.) are on the market.—(*Chem.-Zeit.*)



## Carbonization of Coal

**Rapid Advances Being Made in Coal Distillation Field—Semi-Coke and Carbocoal With Accompanying High Yields of Tars Rich in Oils**

By WALLACE SAVAGE

THE phenomenon of coal carbonization involves highly complex chemical reactions in three phases—the solid fixed carbon, or coke; liquid products, water and tar; and gas. The yield and character of these products vary widely with the nature of the coal and the physical conditions of temperature, pressure, time and contact surfaces. In commercial practice, it is known that practically none of the final products are liberated as such from the coal. Secondary reactions among the primary products have been studied and are

tially unaltered; at 450 deg. F. decomposition into paraffin oils, gases and solid substances begins, the mass fuses, swells and loses weight, and if distillation is completed, a porous coal is left; at 750 deg. F. new gases and vapors are liberated accompanied by a marked increase in the volume of the mass and the development of a very porous cellular structure; at from 825 to 980 deg. F. the liberation of oils is more rapid and in one hour a 36 per cent volatile coal is reduced fifty per cent in volatility and the apparent specific gravity of the residue to

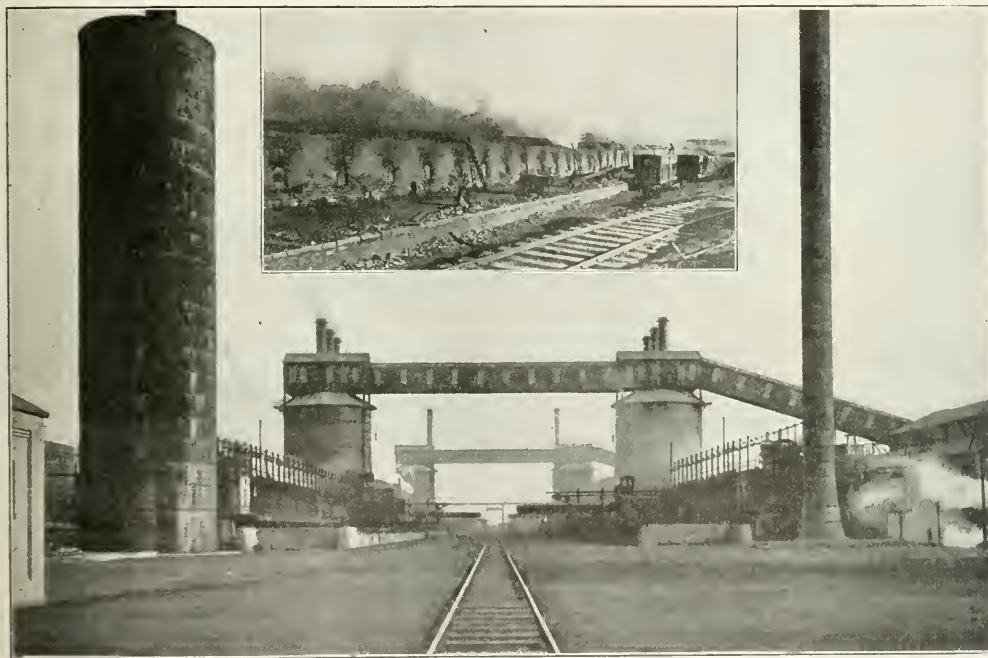


FIG. 1.—THE BY-PRODUCT COKE OVENS AT GARY, INDIANA; BEE HIVES AT BLOSSBERG, NEW MEXICO

known to follow well-known physical-chemical laws. However, the application of chemical statics and dynamics to coal carbonization does not offer a means of simplifying results because of the number of the components in such a system, the only certain factor known being the maximum heat—no average temperature or pressures being determinable. The process may be divided into stages: From 215 to 225 deg. F. the moisture is removed; from 300 to 400 deg. F., a slight superficial softening of the coal takes place and some gases are given off, but the character of the fuel is substan-

about 0.75; at very high temperatures—1500 to 3000 deg. F.—the volatile hydrocarbons are practically entirely removed and the carbon residue fused to great hardness.

In the manufacture of metallurgical coke, the beehive oven has yielded a satisfactory product from coals as high as 32 per cent in volatile matter, while with by-product ovens, the best results are obtained by utilizing harder coals of from 23 to 28 per cent volatile matter. Coals having above 4 per cent moisture content produce inferior results. During the past twelve years, the in-

stallation of by-product ovens in the United States has been phenomenal, practically doubling every four years. In Fig. 1, the story is told comparatively, the familiar bee-hive is hidden in a swarm of black tar condensates and smoke, while the Gary by-product coke plant is a strick observer of the anti-smoke laws. Now that our by-product coke production has about caught up with that of the bee-hive and we are soon to have about five million gallons of coke oven tar per week, a new source with a new type of tar looms into sight, that may revolutionize both our fuel and our coal oil industries.

#### LOW TEMPERATURE DISTILLATION SEMI-COKE

In 1890, Parker devised a process (Eng. Pat. No. 67) for producing a smokeless fuel by passing steam, water gas, or coal gas superheated to a temperature of 1100 to 1200 deg. F. through a mass of fused coal. The idea of using an inert gas as a heating medium did not give results and after years of investigation, Parker took out his famous Coalite Patent (Eng. Pat. 14,365, 1906) on externally heating coal in the presence of steam to



FIG. 2. BRIQUETTED SEMI-COKE AND FINISHED CARBOCOAL

around 800 deg. F. A number of retorts were tried, details of which are recorded in the English patent files from 1906 to 1911. The first proposal was to use the gas D-shaped retorts about 5 ft. wide, 7 ft. long and 16 in. high, the layer of coal being spread 6 in. thick. Coals with low melting points were distilled in tapering cylinders of about 11 to 12 in. in diameter, a gas outlet being connected with the usual tar recovery appliances. Since these proved unsuccessful, vertical retorts of flat oblong cross-section were tried, with no more success. Next a boiler tube system was installed, batteries of 4- to 6-in. pipes in a fire box being connected with the hydraulic main. These continued alterations in designs furnish an interesting commentary upon the persistence of the Coalite Company in trying to overcome their heating difficulties. The Coalite failures have not led to discouragement, for the work has been carried on in America and the goal apparently reached by the International Coal Products Company.

#### CARBONIZED SEMI-COKE BRIQUETS

In 1915, Charles Howard Smith<sup>1</sup> undertook to manufacture coke by an entirely new process. He proposed to get an intermediate soft 16 to 20 per cent volatile semi-coke, briquet it with hard pitch under high pressure, and carbonize at suitable temperatures. Fig. 2 shows the green and carbonized briquet product now being marketed under the name of "Carbocoal." This

fuel has been tested by several railroads and the U. S. Navy. It burns more freely than coke. With a rate of combustion of 27 lb. per sq.ft. of grate per hour, it evaporated 12.8 lb. of water per lb. of fuel; and with a 100-lb. combustion rate, 8.5 lb. of water. A maximum combustion rate of 166 lb. per sq.ft. of grate surface per hour has been reached. The air space is absolutely constant with this type of fuel. By adding certain minerals to the raw briquets, the melting point of the ash can be raised, so that the fusion of the ash to clinkers is prevented. There is no waste such as breeze etc., as all the accumulated fines are incorporated into the briquets. However, as previously indicated, the



FIG. 3. SEMI-COKE BRIQUETS

Falling from the Machine to a Belt Conveyor, Leading to the Carbocoal Retorts

Smith process is not confined to fuel manufacture, its main feature being in the production of 30 gal. of water-free tar per ton of 35 per cent volatile coal—an increase of from three to four times over ordinary tar yields.

#### SMITH PROCESS

In the Smith process, any grade of bituminous coal is reduced to about twelve mesh and fed continuously by a conveyor through a compound cylindrical retort having a double system of propelling paddle agitators mounted on two shafts. The retort is built of a refractory material of the carborundum type. The speed of the agitator is about four revolutions per hour, the design being such that the material is subjected to distillation for about one hour. The walls of the retort are heated to about 900 deg. F. externally by the combustion of the gas evolved in the process, checkerwork preheaters being installed below the fire box to make this possible. The retort discharges into an attached

<sup>1</sup>U. S. Pat. 1,177,727 and 1,224,424.

iron hopper, where the semi-coke cools off and is discharged at intervals on to a conveyor which carries it to

to the present time, only 4 or 5 per cent is left, this product burning freely in an open fireplace.



FIG. 4. INCLINED RETORT DURING CONSTRUCTION

a large crusher and Williams hammer mill where it is pulverized.

The finely divided semi-coke is mixed with several per cent of briquet pitch and thoroughly blunged in a direct steam-heated mixing machine. The hot pitched coke is fed into a briquetting machine of the roller type giving about two hundred and fifty briquets to the revolution. In Fig. 3 this machine is shown in operation. A conveyor carries the steaming green briquets to a hopper above the inclined retort feed doors. Fig. 4 shows an exposed retort during construction and Fig. 5 a group of retort ovens, the roofed structure at the left being a vertical Glover West retort, and the others being a single and a triple bank of 35-degree inclined retorts. The inclined retort has proved most satisfactory, the finished briquets discharging by gravity to a coke carriage in which they are quenched. The degree of carbonization in the inclined retorts could be carried to any predetermined extent, so that any amount of volatile matter can be left. Up

#### CONDENSING THE VOLATILES

In the low temperature retorting of the pulverized coal, the average contents of the retort are constant, because of the continuous feed. The evolution of gases is strongest at the discharge end, so that an additional outlet is connected with the gas main in conjunction with a central connection. A water seal is placed in the line at a considerably lower level than in gas practice, so that a shallower dip with a corresponding decrease in resistance to flow of gas and less back pressure in the retort is obtained. The hot gases are freed of solids and liquids as in ordinary gas practice. Table I indicates the main divisions of the products and their amounts.

TABLE I—PRODUCTS OF THE CARBOCOAL PROCESS

|                    |                                                                              |   |   |   |                                                                                                                                         |
|--------------------|------------------------------------------------------------------------------|---|---|---|-----------------------------------------------------------------------------------------------------------------------------------------|
| Coal,<br>2,000 lb. | Carbocoal<br>briquets,<br>1440 lb.                                           | { | { | { | Benzol, toluol, naphthas, motor<br>spirits, creosote oils, tar acids,<br>lubricating and fuel oil, pitch<br>and other tar oil products. |
|                    | Tar oils,<br>250 lb.                                                         |   |   |   |                                                                                                                                         |
|                    | Vapors,<br>360 lb.                                                           |   |   |   |                                                                                                                                         |
|                    | Ammonia,<br>20 lb.                                                           |   |   |   |                                                                                                                                         |
|                    | Gas and<br>vapors,<br>560 lb.                                                |   |   |   |                                                                                                                                         |
|                    | Permanent gases<br>required in the distillation process for heat,<br>200 lb. |   |   |   |                                                                                                                                         |

#### THE TAR AND ITS PRODUCTS

The tar obtained in the primary distillation of the coal has a specific gravity of 1 to 1.06, due to its large content of oils. A peculiarity of this tar is that it contains no naphthalene, anthracene or carbolic acid, but is rich in oils, tar acids and cresols which would indicate that the former are products formed from the

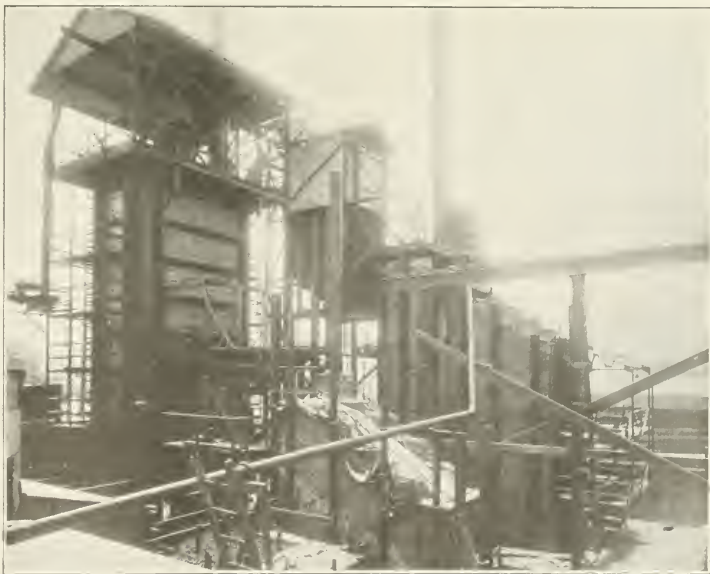


FIG. 5. EXPERIMENTAL RETORTS AT NEWARK, N. J.



latter under higher temperature conditions. Chart I gives a diagrammatic view of the coal tar industry and a partial list of the immense number of commercial products derived from it. From being an undesirable waste product, it is rapidly advancing to be an absolute necessity, with an unlimited consumption for its products.

In obtaining a high yield of benzol and toluol, the light condensates are passed through long, highly heated tubes, where the gas retort wall effect is reproduced.

### THE FUTURE OF COAL CARBONIZATION

A large, low-temperature coal distillation plant is now being built at Clinchfield, Virginia. The Government is backing the Smith process there with a view to getting coal-tar oils for the manufacture of explosives and a fuel for the Navy that is as flexible and smokeless in combustion as fuel oil. Carbocool is considered to have been sufficiently advanced beyond the experimental stage at the Newark plant to justify going into a larger

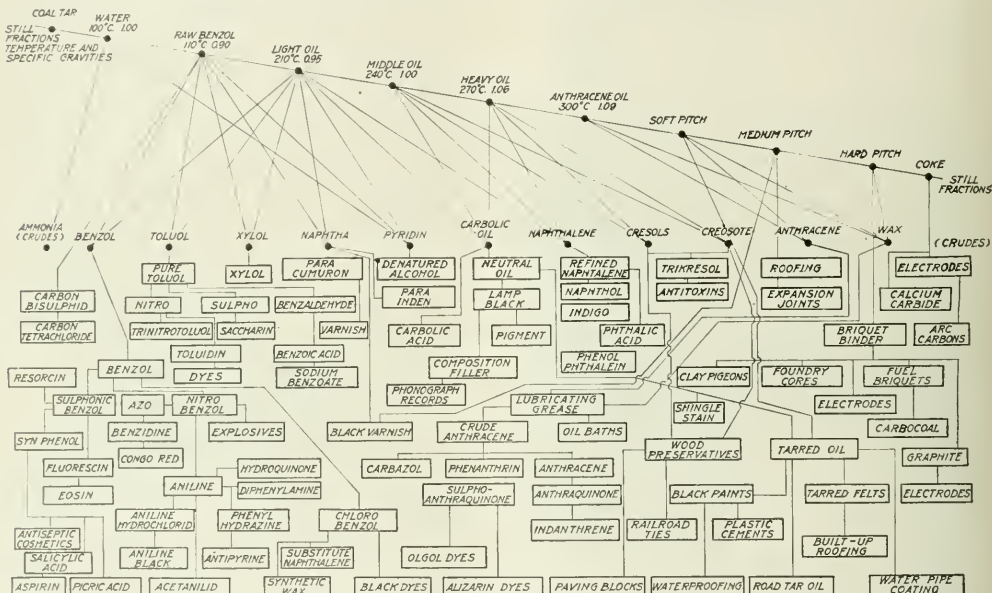


CHART I.—PRIMARY TAR FRACTIONS AND THEIR COMMERCIAL PRODUCTS

giving a large yield of pure aromatics. Table II gives the tar products produced per ton of coal. It will be noticed that an increase of the products in this process

TABLE II—RECOVERY OF LIQUID PRODUCTS PER TON OF RAW COAL

| Distillation Temperature, Deg. F. | By-Product Coke Oven |          | Carbocool, First Distillation |          | Carbocool, Second Distillation |          |
|-----------------------------------|----------------------|----------|-------------------------------|----------|--------------------------------|----------|
|                                   | Gal.                 | Per Cent | Gal.                          | Per Cent | Gal.                           | Per Cent |
| Light oil, ..... 0-170            | 0.27                 | 3.47     | 1.58                          | 6.60     | 0.003                          | 0.05     |
| Middle oil, ..... 170-230         | 0.44                 | 5.85     | 3.29                          | 13.70    | 0.036                          | 0.60     |
| Cresote oil, ..... 230-270        | 0.78                 | 10.37    | 3.11                          | 12.95    | 0.126                          | 2.10     |
| Heavy oil, ..... 270-360          | 1.26                 | 16.81    | 8.88                          | 37.00    | 2.485                          | 41.42    |
| Pitch, ..... 360-400              | 4.66                 | 62.18    | 6.90                          | 28.75    | 3.290                          | 54.83    |
| Loss, ..... 400-450               | 0.09                 | 1.32     | 0.24                          | 1.00     | 0.060                          | 1.00     |
| Totals, ..... 450-500             | 7.50                 | 100.00   | 24.00                         | 100.00   | 6.000                          | 100.00   |

over standard by-product coke-oven practice is mainly in the oils, the factors being: light oil, 6; middle oil, 8; cresote oil, 4; heavy oil, 9; and pitch, 2. Without subsequent cracking, there will be a considerable percentage of paraffin oils, but as the supplies of benzol etc. from other sources will soon be more than can be consumed in the chemical industries, these oils will probably be used direct as solvents and motor fuel. The pitch will be low in free carbon, so that if used by itself, it would have a rather high temperature susceptibility (i.e. soften rapidly with heat); however, it can be compounded with the coke oven tars to give very satisfactory products.

undertaking. If the final outcome is as anticipated, Carbocool will release vast amounts of petroleum fuel, will furnish great quantities of coal tar products, and if developed to its full possibilities, will aid immensely in giving our cities a clear sky line and an atmosphere unpolluted by tar. Mention might also be made that the saving in laundry soap might not be a negligible item in the economies effected.

Upon a brief survey of the possibilities presented in this coking process, the main items aside from the advantages of the refined carbocool are the demand for motor engine fuel, road tars and cresote oils. Undoubtedly, the prices of these commodities shall advance to a point commanding sufficient production to equal their requirements. The ten per cent consumption of raw material for fueling the process is not a large expenditure. The cost accountant probably will have no difficulty charging the major products alone with all the manufacturing costs. The waste of the beehive coke ovens has been spoken of on the platform and in the press for years. Now that great things have been accomplished with by-product coke ovens, the sequence is naturally to extend their scope. Should the results warrant the confidence now reasonably put in the Smith process, the extent to which the coal tar industry can grow is unbounded.

# The Metallography and Heat-Treatment of Metals Used in Aëroplane Construction—V

## Results of Tests to Determine the Best Brazing Materials and Fluxes—Strength of Brazed Joints—Beneficial Effect of Heat Treatment—Comparison of Brazed and Welded Joints

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### INVESTIGATION OF BRAZING MATERIALS

**T**HE object of this investigation was to determine (a) the best metal for making brazed joints between milled steel fittings, and (b) the best flux for the same. The materials used were various copper alloys and different fluxing materials.

Cold-drawn steel bars 8 in. long and  $\frac{1}{2}$  in. hexagon cross-section were butt-brazed, and the tensile strength of the joints taken. In a certain number of cases experiments were repeated with different fluxes; in others the brazed bars were subjected to heat-treatment. The brazing in a part of the series was done with an oxy-acetylene torch; in the other cases, with a fire produced by two gas blow-pipes so adjusted that the tips of the inner flame touched the metal.

In the first series of experiments joints were made with five different brazing metals by means of the acetylene torch, one each with a mixture of five parts boracic acid and one part borax mixed to a paste with water and applied wet to cold metal, and with zinc chloride similarly applied. The resulting tensile

TABLE I. STRENGTH OF BUTT-BRAZED JOINTS

| Exp. No. | Brazing Metals | Boric Acid Flux— |             | Zinc Chloride Flux— |             |
|----------|----------------|------------------|-------------|---------------------|-------------|
|          |                | Load             | Lb. Sq. In. | Load                | Lb. Sq. In. |
| 1        | Wire 116-1     | 6,840            | 31,500      | 2,590               | 11,900      |
| 2        | Wire 116-2     | 6,410            | 29,500      | 3,070               | 14,100      |
| 3        | Wire 116-3     | 7,650            | 35,000      | 1,900               | 7,700       |
| 4        | Wire 116-4     | 6,760            | 31,000      | 3,170               | 14,400      |
| 5        | Wire 116-5     | 6,880            | 31,750      | 3,000               | 13,800      |

strengths are given in Table I. With zinc chloride the joints were only partially covered with braze, and the flow was very poor. Preliminary experiments with quartz sand, sodium carbonate, and a mixture of the two gave negative results.

The melting points and compositions of the five different samples of brazing wire are given in Table II.

TABLE II—MELTING POINTS AND COMPOSITION OF BRAZING METALS

| Wire  | Melting Point | Copper, Per Cent | Zinc, Per Cent | Tin, Per Cent | Iron, Impurities, Per Cent |
|-------|---------------|------------------|----------------|---------------|----------------------------|
| 116-1 | 1,590         | 56.76            | 42.18          | 0.45          | Trace                      |
| 116-2 | 1,610         | 60.18            | 39.07          |               | 0.65                       |
| 116-3 | 1,614         | 59.22            | 39.61          | 0.27          |                            |
| 116-4 | 1,603         | 66.52            | 32.78          |               | 0.70                       |
| 116-5 | 1,602         | 60.70            | 38.45          |               | 0.75                       |

Joints made by means of the acetylene torch, using the boric acid and borax mixture as flux, and various brazing metals, gave the results shown in Table III.

TABLE III—RESULTS OF BRAZING WITH VARIOUS METALS

| Exp. No. | Brazing Metal                | Load  | Lb. Sq. In. |
|----------|------------------------------|-------|-------------|
| 6        | Brass No. 128-1              | 5,990 | 27,500      |
| 7        | Brass No. 128-2              | 6,170 | 28,400      |
| 8        | No. 128-3                    | 6,220 | 28,600      |
| 9        | Copper and brass equal parts | 6,790 | 31,300      |
| 10       | Copper 2 pt. Brass 1 pt.     | 7,050 | 32,500      |
| 11       | Copper, sheet                | 6,870 | 31,800      |
| 12       | Scrap cud brass              | 6,70  | 30,090      |
| 13       | Spelter (condemned)          | 9,080 | 41,800      |

Six joints made in the gas fire with sheet copper gave the results shown in Table IV.

TABLE IV—RESULTS OF BRAZING IN GAS FIRE WITH SHEET COPPER

| Exp. No.     | Metal    | Load   | Lb. Sq. In. |
|--------------|----------|--------|-------------|
| 22           |          | 7,300  | 33,700      |
| 23           |          | 6,500  | 29,800      |
| 24           |          | 8,190  | 38,200      |
| 25           |          | 7,650  | 35,200      |
| 26           |          | 8,650  | 39,800      |
| 27           |          | 2,800  | 21,000      |
| Average..... |          | 7,186  | 33,200      |
| 28           | 116-1    | 9,370  | 43,100      |
| 29           | 116-2    | 6,980  | 32,100      |
| 30           | 116-Soft | 10,550 | 47,500      |
| 31           | 116-4    | 9,700  | 44,600      |
| 32           | 116-5    | 10,970 | 50,500*     |
| 33           | 128-3    | 10,690 | 49,300      |
| 34           | 11-Tobin | 10,720 | 49,400      |
| 35           | 10-Soft  | 10,990 | 50,000*     |

\* Steel parted.

Joints made by use of acetylene torch with three different silver solders were tested, with results given in Table V.

TABLE V—TEST OF JOINTS MADE WITH SILVER SOLDER

| Exp. No. | Metal        | Load   | Lb., Sq. In. |
|----------|--------------|--------|--------------|
| 36       | Silver No. 1 | 8,590  | 39,500       |
| 37       | Silver No. 2 | 10,020 | 46,000       |
| 38       | Silver No. 3 | 11,561 | 53,200*      |

\* Steel parted.

### CONCLUSIONS ON INVESTIGATION OF BRAZING MATERIALS

The joints brazed in the gas fire, using copper-zinc alloys with boric acid flux, nearly all exceeded the maximum strength of steel used.

Pure copper does not give as good results as alloys. It does not flow as well, and it is more difficult to produce a perfect joint with it.

With copper-zinc brazing alloys boric acid leaves little to be desired as a flux. It melts and flows freely, and dissolves the oxides readily. It is preferable to borax in that it is free from the frothing caused by the water of crystallization in commercial borax, and hence is easier to handle on the hot metal. It makes no difference how it is applied as long as a sufficient amount is fused on the joint to insure a complete cleaning of the metal.

### STRENGTH OF BRAZED JOINTS; EFFECT OF HEAT-TREATMENT

The object of the investigation was to determine (1) the relative strength of joints brazed with brazing metal of different compositions (a) brazed with acetylene torch, and (b) brazed in a gas fire; and (2) to determine the effect of heat-treating on joints brazed with torch and with gas fire.

(1) Bars of cold drawn  $\frac{1}{2}$ -in. hexagon steel were butt-brazed with different metals by the two methods of heating and the tensile strength of the joint taken.

(2) A series of bars as brazed, and one-half of them heat-treated by heating to 1600-1625 deg., quenching in oil and drawing at 900 deg., after which the tensile strength of the joints was taken.

**Preparation of Brazing Metal.** A brazing metal was made by melting together 6 lb. of copper and 1½ lb. of zinc under a borax flux, and allowing the melt to cool in the crucible. The ingot obtained was then sawed in two, and one of the halves remelted, and a bar made by pouring a portion into a mold. The ingot and the bar showed the following percentage composition by analysis:

|            | Copper | Zinc  | Iron  | Bismuth | Lead  |
|------------|--------|-------|-------|---------|-------|
| Ingot..... | 81.74  | 18.20 | 0.06  | Trace   | Trace |
| Bar.....   | 82.60  | 17.30 | Trace | Trace   | Trace |

The bar was used to make twelve joints each with the acetylene torch and the gas fire; and one-half of each of these sets was heat-treated.

The tensile strengths were then taken with results shown in Table VI. Increase in strength of torch braze,

TABLE VI.—STRENGTH OF COPPER-ZINC BRAZED JOINTS

| Exp. No.     | Torch Braze |             | Exp. No.     | Fire Braze |             |
|--------------|-------------|-------------|--------------|------------|-------------|
|              | Load        | Lb. Sq. In. |              | Load       | Lb. Sq. In. |
| 39           | 10,390      | 47,500      | 45           | 7,150      | 32,900      |
| 40           | 7,800       | 35,800      | 46           | 9,610      | 43,200      |
| 41           | 9,070       | 41,700      | 47           | 9,470      | 43,600      |
| 42           | 10,390      | 37,500      | 48           | 11,280*    | 51,500      |
| 43           | 6,880       | 40,000      | 49           | 7,150      | 32,900      |
| 44           | 10,420      | 48,000      | 50           | 7,860      | 36,200      |
| Average..... | 43,416      |             | Average..... | 40,050     |             |

\* Steel parted.

average 3366 lb. sq.in., 8.4 per cent; minimum strength, torch 35,800; fire, 32,900; excess of torch, 2900 lb. sq.in., 8.8 per cent.

The bars that were heat-treated after the brazing gave the results shown in Table VII. Average increase

TABLE VII.—EFFECT OF HEAT-TREATMENT ON BRAZED JOINTS

| Exp. No.     | Torch Braze |             | Exp. No.     | Fire Braze |             |
|--------------|-------------|-------------|--------------|------------|-------------|
|              | Load        | Lb. Sq. In. |              | Load       | Lb. Sq. In. |
| 51           | 10,280      | 47,400      | 57           | 9,130      | 42,000      |
| 52           | 12,220      | 56,100      | 58           | 8,580      | 39,500      |
| 53           | 10,980      | 50,500      | 59           | 8,550      | 39,500      |
| 54           | 9,380       | 43,100      | 60           | 10,630     | 46,000      |
| 55           | 10,820      | 47,400      | 61           | 8,960      | 41,000      |
| 56           | 10,300      | 47,400      | 62           | 7,950      | 36,800      |
| Average..... | 48,650      |             | Average..... | 40,800     |             |

of heat-treated over untreated: torch, 5234 lb. sq.in.; fire, 750 lb. sq.in.; per cent increase, torch 12 per cent., fire 0.2 per cent.

A metal was made by melting together 85 parts of copper and 15 parts zinc, remelting and ingot and casting a bar which analyzed 87 per cent copper and 12.4 per cent zinc. With this metal used in a fire braze on the hexagon rods, results were obtained as given in Table VIII. The results showed such inferiority that no further test was made with this metal.

TABLE VIII.—TESTS OF COPPER-ZINC BRAZING METAL

| Exp. No. | Load  | Lb. Sq. In. |
|----------|-------|-------------|
| 63       | 6,790 | 31,200      |
| 64       | 6,860 | 31,600      |
| 65       | 6,020 | 37,000      |
| 66       | 6,700 | 30,800      |
| 67       | 7,970 | 36,800      |
| 68       | 8,630 | 39,800      |

A metal made by melting together 305 g. copper, 62 g. zinc and 4 g. tin gave results, with a fire braze, shown in Table IX. These results did not warrant further tests of this metal.

TABLE IX.—TESTS OF COPPER-ZINC-TIN BRAZING METAL

| Exp. No. | Load  | Lb. Sq. In. |
|----------|-------|-------------|
| 69       | 6,760 | 31,000      |
| 70       | 6,910 | 31,900      |
| 71       | 5,780 | 26,800      |
| 72       | 6,970 | 32,000      |
| 73       | 6,760 | 31,100      |
| 74       | 7,450 | 39,100      |

### CONCLUSIONS ON STRENGTH OF BRAZED JOINTS

Joints made with the acetylene torch were distinctly stronger than those made in the gas fire.

The brazing metal containing 83 per cent copper and 17 per cent zinc gave strongest joints.

Heat-treatment of the joints acetylene-brazed gave a marked increase in strength.

**Remarks.** The results obtained demonstrated that it is practical to make brazed joints that will be materially improved by heat-treating the steel after brazing. Brazing metal containing from 20 per cent to 15 per cent zinc has a sufficiently high melting-point to admit of heat-treatment and flows well in operation.

### INVESTIGATION OF BRAZED AND WELDED JOINTS

The object of this investigation was to determine the effects of heat-treatment on joints brazed with different brazing metals, and a comparison of the relative strength of brazed and acetylene-welded joints.

**Materials.** Cold-drawn seamless steel tubing, and brass and copper for brazing metal.

Sections of tubing were cut 6 in. long. These were respectively 1 in. and ½ in. outside diameter and both of 16 gage. The larger diameter pieces were cleaned out at one end by means of a reamer, and the ends of the smaller pieces were cleaned off by filing in the lathe. This preparation provided joints free from scale, and also permitted the smaller tube to telescope the larger with a free fit. Fifty pairs of these tubes were prepared, comprising five series of experiments of ten each:

- Dip-brazed, with standard brazing brass
- Gas-brazed, with standard brazing brass
- Oxyacetylene-brazed, with standard brazing brass
- Oxyacetylene-brazed, with pure copper
- Oxyacetylene-welded

One-half, i.e., 5 pairs of each series (except A, all of which were heat-treated by mistake) were heat-treated after brazing, by heating to 1600 deg., oil quenching, and drawing to 900 deg.

In each series a part of the joints were ⅜ in. length, i.e., the smaller tube telescoped the larger ⅜ in.; a portion were ½ in., and the remainder ¾ in.

Boric acid was used as the flux.

After the joints were made and heat-treated, the pieces were cleaned by sandblast and any fillets that had been formed were filed away.

Series B and C were brazed with the brass described in the previous report, containing 82.6 per cent copper and 17.3 per cent zinc, which is practically the composition of the government specification brazing metal. Series A was made with a metal not substantially different. A piece of copper tubing was used in Series D.

The completed pieces were subjected to test for tensile strength. The results are given in Tables X, XI, XII, XIII and XIV.

TABLE X.—SERIES A, DIP-BRAZED, STANDARD BRASS

| Not Heat-treated |           |                  |                        | Heat-treated |           |                  |                        |
|------------------|-----------|------------------|------------------------|--------------|-----------|------------------|------------------------|
| Exp. No.         | Joint In. | Yield Point, Lb. | Ultimate Strength, Lb. | Exp. No.     | Joint In. | Yield Point, Lb. | Ultimate Strength, Lb. |
| 75               | ⅜         | .....            | 3,910*                 | 80           | ⅜         | .....            | 5,770*                 |
| 76               | ⅜         | .....            | 8,300                  | 81           | ⅜         | 8,120            | 10,810                 |
| 77               | ⅜         | .....            | 10,860                 | 82           | ⅜         | 8,333            | 10,870                 |
| 78               | ⅜         | .....            | 9,660*                 | 83           | ⅜         | .....            | 10,970                 |
| 79               | ⅜         | .....            | 9,250*                 | 84           | ⅜         | .....            | 11,030*                |

Average 9,400; min. 3,910.

\* Joint pulled apart.

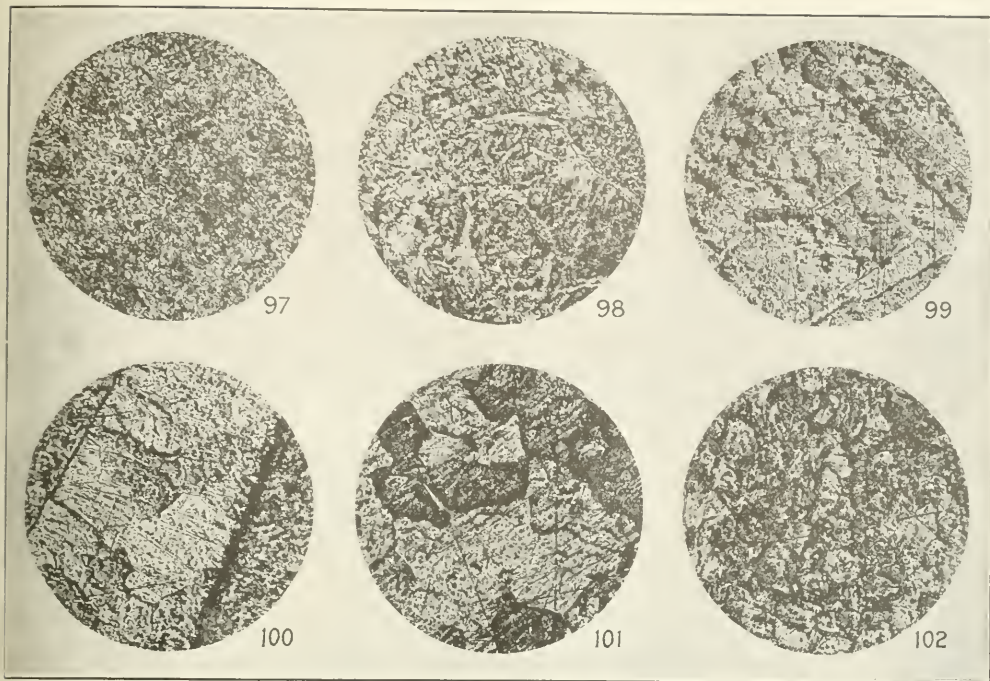
TABLE XI.—SERIES B, BRAZED IN GAS FIRE, STANDARD BRASS

| Not Heat-treated |           |                  |                        | Heat-treated |           |                  |                        |
|------------------|-----------|------------------|------------------------|--------------|-----------|------------------|------------------------|
| Exp. No.         | Joint In. | Yield Point, Lb. | Ultimate Strength, Lb. | Exp. No.     | Joint In. | Yield Point, Lb. | Ultimate Strength, Lb. |
| 85               | ⅜         | 5,910            | 9,600                  | 91           | ⅜         | .....            | 11,680                 |
| 86               | ⅜         | .....            | 9,400                  | 91           | ⅜         | 7,950            | 11,520                 |
| 87               | ⅜         | .....            | 9,770*                 | 92           | ⅜         | .....            | 9,350*                 |
| 88               | ⅜         | .....            | 5,050*                 | 93           | ⅜         | .....            | 3,560*                 |
| 89               | ⅜         | .....            | 8,430*                 | 94           | ⅜         | .....            | 7,500*                 |

Average 8,580; min. 3,560.

\* Joint pulled apart.





FIGS. 97 TO 102

Fig. 97—Joint made with acetylene torch. Fig. 98—Joint made with gas torch. Figs. 99 to 102—Welds and brazes. Heat treatments given 1600-1625 deg.; quenched in oil and drawn at 1000 deg.; x 100. Fig. 99—Untreated joint, picric acid etch; 100—Treated brazed joint; 101—Untreated weld, picric acid etch; 102—Treated weld.

TABLE XII—SERIES C, BRAZED WITH OXYACETYLENE TORCH, STANDARD BRASS

| Exp. No. | Untreated  |                  |                        | Exp. No. | Heat-treated |                  |                        |
|----------|------------|------------------|------------------------|----------|--------------|------------------|------------------------|
|          | Joint, In. | Yield Point, Lb. | Ultimate Strength, Lb. |          | Joint, In.   | Yield Point, Lb. | Ultimate Strength, Lb. |
| 95       | 1/8        | .....            | 9,850*                 | 100      | 1/8          | .....            | 11,320*                |
| 96       | 1/8        | .....            | 10,340*                | 101      | 1/8          | .....            | 11,260                 |
| 97       | 1/8        | .....            | 10,250                 | 102      | 1/8          | .....            | 11,750                 |
| 98       | 1/8        | .....            | 11,750                 | 103      | 1/8          | .....            | 10,380                 |
| 99       | 1/8        | .....            | 10,370                 | 104      | 1/8          | 8,850            | 9,540*                 |

Average 11,679; min. 9,540.

\* Joint pulled apart.

TABLE XIII—SERIES D, BRAZED WITH ACETYLENE TORCH, PURE COPPER

| Exp. No. | Untreated  |                  |                        | Exp. No. | Heat Treated |                  |                        |
|----------|------------|------------------|------------------------|----------|--------------|------------------|------------------------|
|          | Joint, In. | Yield Point, Lb. | Ultimate Strength, Lb. |          | Joint, In.   | Yield Point, Lb. | Ultimate Strength, Lb. |
| 105      | 1/8        | 7,050            | 8,200                  | 100      | 1/8          | .....            | 10,390*                |
| 106      | 1/8        | 7,210            | 10,100*                | 111      | 1/8          | 7,880            | 8,290*                 |
| 107      | 1/8        | .....            | 10,200                 | 112      | 1/8          | .....            | 10,660                 |
| 108      | 1/8        | .....            | 10,000                 | 113      | 1/8          | .....            | 11,050                 |
| 109      | 1/8        | .....            | 8,100*                 | 114      | 1/8          | .....            | 10,930                 |

Average 9,792; min. 8,100.

\* Joint pulled apart.

TABLE XIV—SERIES E, OXYACETYLENE WELDED

| Exp. No. | Untreated  |                  |                        | Exp. No. | Heat Treated |                  |                        |
|----------|------------|------------------|------------------------|----------|--------------|------------------|------------------------|
|          | Joint, In. | Yield Point, Lb. | Ultimate Strength, Lb. |          | Joint, In.   | Yield Point, Lb. | Ultimate Strength, Lb. |
| 115      | 1/8        | .....            | 8,280*                 | 120      | 1/8          | 8,280*           | 9,180*                 |
| 116      | 1/8        | .....            | 8,830*                 | 121      | 1/8          | 8,840            | 9,180*                 |
| 117      | 1/8        | 6,900            | 10,200*                | 122      | 1/8          | .....            | 10,400*                |
| 118      | 1/8        | .....            | 10,000*                | 123      | 1/8          | .....            | 10,800*                |
| 119      | 1/8        | .....            | 10,131*                | 124      | 1/8          | .....            | 11,260*                |

Average 8,936; min. 8,280.

\* Joint pulled apart.

The 1/8-in. tubing alone, without any treatment, gave a yield point of 8,760, and ultimate strength of 9,550 pounds.

A pair of tubes, brazed with the acetylene torch, meeting but not telescoped, the joint consisting only of a

fillet flush with the larger tube gave a yield point of 7000 and ultimate strength of 10,390 lb., the smaller tube parting, leaving the joint intact.

#### CONCLUSIONS ON BRAZED AND WELDED JOINTS

(1) The best brazed joints, all points considered, were obtained with standard brazing metal, made with the acetylene torch and heat-treated. The joints showed (a) the highest average ultimate strength, (b) the highest minimum strength (c) the highest yield point, and (d) the smallest proportion pulling apart at the joint.

(2) The methods of brazing, considered with reference to the above points, ranked as follows: (a) acetylene torch, (b) dip, (c) gas fire.

(3) The best brazing metal was the standard brass.

(4) All welded joints were weaker than the ultimate strength of the tubing.

(5) The average strength of heat-treated brazed joints was 9.6 per cent higher than that of the untreated.

(6) In only one case did a brazed joint formed by a lap of 1/4 in. pull apart, and in that case the ultimate strength was over 11,000, which is considerably above the normal strength of the tubing.

*Remarks.* In the case of brazed joints made under the best conditions, as previously described, with steel that has been subject to cold-working, as drawn tubing or cold-rolled sheet, and untreated, the weakest part is the steel above the joint where it is subjected to the heat of the flame during the brazing process. The 100

per cent efficient brazed joint is therefore entirely practical, and could probably be substituted to advantage in many cases where welding is now practiced.

The superiority of brazing done by the acetylene torch over that done with a gas fire was referred to previously; further experiments confirm those conclusions.

The greater strength of the joints made by the acetylene torch are apparently due to a difference in the physical condition of the metal. Micrographs of joints made with the same metal by the two different methods of heating show marked variations in structure, that made with the acetylene torch having a very fine grain, while the other shows a coarse crystalline structure, as will be seen by reference to Figs. 97 and 98 respectively.

Analysis of the metal in joints made in the same series of experiments shows that the acetylene torch reduces the zinc content of the metal 6 per cent, while the gas fire reduces it only 2 per cent.

|                                              |        |      |
|----------------------------------------------|--------|------|
|                                              | Copper | Zinc |
| Composition of metal before brazing          | 82.6   | 17.3 |
| Composition of metal after acetylene-brazing | 88.8   | 11.2 |
| Composition of metal after gas fire-brazing  | 84.6   | 15.4 |

The difference in composition, however, does not account for the difference in strength; in fact, the reverse would be expected, since the strength of copper-zinc alloys normally decreases as the zinc content decreases through this range of proportions. Joints brazed with a metal of almost identical composition to the acetylene joint showed very inferior strength. (See experiments 63-68.) It seems probable that as a result of the conditions produced by the acetylene torch, beta crystals of copper-zinc solid solution are formed which remain after cooling. The fact that these joints show a pink color on fracture (Fig. 97), while the others have the pure yellow color of the alpha crystals (Fig. 98) tends to confirm this opinion. Whatever the cause, there is no doubt that the torch-brazed joints are stronger, and that their strength is further increased in the process of heat-treating the steel.

#### FURTHER INVESTIGATION OF BRAZING VS. WELDING

The object of this series of tests was to determine:

- (1) The relative strengths of brazed and welded joints;
- (2) the effect of heat-treating on brazed joints; and
- (3) the effect of heat-treatment on welded joints.

**Materials.** Strips of cold-rolled sheet steel, 7 in. x 0.925 x 0.1; brass containing 87 per cent copper; boric acid flux, and still wire for welding.

**Method.** Ten pairs of steel strips were butt-brazed with the acetylene torch, and ten pairs butt-welded, the work being done carefully by experienced workmen. One-half each of the brazed and welded bars were then given the prescribed heat-treatment for this grade of steel, viz.: heating to 1600 to 1625 deg., quenching in oil,

TABLE XV.—TENSILE STRENGTH OF BRAZED AND WELDED JOINTS  
(Pounds maximum load)

| Brazed               |           |          |         | Welded   |           |          |         |
|----------------------|-----------|----------|---------|----------|-----------|----------|---------|
| Exp. No.             | Untreated | Exp. No. | Treated | Exp. No. | Untreated | Exp. No. | Treated |
| 125                  | 5,160     | 130      | 6,270   | 135      | 4,060     | 140      | 5,220   |
| 126                  | 5,015     | 131      | 5,995   | 136      | 4,295     | 141      | 5,685   |
| 127                  | 4,370     | 132      | 6,270   | 137      | 4,985     | 142      | 6,420   |
| 128                  | 5,770*    | 133      | 5,635   | 138      | 3,670     | 143      | 5,460   |
| 129                  | 5,120*    | 134      | 6,410   | 139      | 5,040*    | 144      | 5,550   |
| Average load, 5,000  | ...       | 6,165    | ...     | 4,400    | ...       | 5,667    | ...     |
| Average per cent     | ...       | ...      | ...     | ...      | ...       | ...      | ...     |
| in. 54,000           | ...       | 66,400   | ...     | 47,500   | ...       | 61,200   | ...     |
| * Steel bar faulted. |           |          |         |          |           |          |         |

and drawing at 900 deg. All the bars were then sand-blasted, and the joints carefully filed down to the dimensions of the bar, after which they were subjected to tests for tensile strength, with the results given in Table XV.

**Comparative Strengths Based on Averages.** Untreated brazed joint is 22.7 per cent stronger than untreated welded joint. See Figs. 99 and 101.

Treated brazed joint is 40 per cent stronger than untreated welded joint. See Figs. 100 and 101.

Treated brazed joint is 8.8 per cent stronger than treated welded joint. See Figs. 100 and 102.

**Effect of Heat-Treatment.** The treated brazed joint is 23.3 per cent stronger than the untreated joint. The treated welded joint is 28.8 per cent stronger than untreated joint.

**Comparative Strengths Based on Minimum Loads.** Untreated brazed joint is 19.2 per cent stronger than untreated welded joint.

Treated brazed joint is 55 per cent stronger than untreated welded joint.

Treated brazed joint is 7.8 per cent stronger than treated welded joint.

Treated brazed joint is 29.5 per cent stronger than untreated joint.

Treated welded joint is 42.3 per cent stronger than untreated joint.

Two out of five untreated brazed joints were stronger than the maximum strength of the steel.

One out of five welded joints was stronger than the maximum strength of the steel.

None of the treated joints were as strong as the steel, showing that heat-treatment strengthens the steel in a greater proportion than it does either the brazed or welded joint.

All of the brazed joints exceeded in strength the yield point of the untreated steel; all but one of the welded joints exceeded the yield point of the steel.

**Conclusions.** On every basis of comparison, in average, minimum, and maximum strength, the brazed joint proved stronger than the welded joint; and in both kinds of joints heat-treating produced a marked increase in strength.

**Remarks.** In these experiments the welding was done under the most favorable conditions for producing a good joint; the pieces were thin enough so that there was no difficulty in heating the joint up to welding temperature, and they were welded on both sides. The brazing conditions were hardly as favorable as the average.

The beneficial effect of heat-treatment of brazed joints confirms the results of former experiments, and leaves no room for doubt of the correctness of the conclusions.

Producer-gas tar or oil is washed with alcohol at a moderate temperature. Air is blown through, forming oxygenated products which are dissolved by the alcohol. The alcohol layer and the undissolved portion are separated and both freed from spirit. The oxygenated products are left as heavy viscous liquid suitable for lubricating wagon axles. The undissolved portions are lighter and can be fractionated into motor spirit and lubricating oil. The necessity for washing with sulphuric acid, with its attendant losses and inconveniences is avoided. D.R.P. 302,398.

# Aluminium and Its Light Alloys—IV

Binary and Ternary Alloys—Conditions Favorable for Casting—Effect of Pouring Temperature on Tensile Strength—Alloys for Rolling and Forging

By PAUL D. MERICA

A VERY comprehensive investigation of the mechanical properties of rolled, binary light alloys of aluminium was carried out in 1915 by Schirmeister (341).

Schirmeister rolled out several compositions of many binary alloys systems of aluminium and tested their hardness and tensile strength. His method of preparation for the alloys was the same for all series and was as follows:

About 900 grams of the alloy was melted in a small gas crucible furnace, poured into a chill mould to plates 25 mm. thick. These were rolled in a 30 hp. mill at the rate of 40 meters per minute. The plates were first reheated after casting to from 400 to 500 deg. C. and rolled with intermediate annealing, with reduction at each pass of from 1 to 3 mm. to a thickness of 4 mm. They were then annealed and rolled cold to from 1.3 to 1.5 mm. thickness. Only those alloys of which the melting point was very considerably lowered by the additions were rolled at lower temperatures or cold. Specimens cut from these sheets were then annealed at from 300 to 370 deg. in a muffle furnace, allowed to cool, and tested after several days.

His results are given in the Table XIV (pg. 588).

## 9. EQUILIBRIA, BINARY AND TERNARY

In Table XV are described the equilibria for binary systems of aluminium as far as they are known; references are given for binary and ternary systems.

It is observed that most metals form compounds with aluminium; the solubility of the aluminium rich compound in the solid aluminium is generally almost zero. The three prominent exceptions to this fact are zinc, copper, and magnesium.

The light alloys of aluminium with these metals contain only small quantities of the added metal, as with increasing amounts the alloy quickly becomes brittle.

Metallographically the light alloys are usually heterogeneous, with a ground mass of almost pure aluminium and crystals of the compound of aluminium with the added metal; these are hard, brittle and more resistant to corrosion than aluminium.

## 10. COMMERCIAL ALLOYS

From the practical standpoint of the relative value of the various alloys which have been studied, the re-

TABLE XV. EQUILIBRIUM DIAGRAMS OF ALUMINIUM ALLOYS

A, B, C..... Binary systems  
D..... Ternary systems

(A) A compound or compounds of the metal with aluminium are formed; the aluminium-rich compound forms a eutectic with aluminium.

| Alloy System                                                                                  | References (*)                                        | Composition of Aluminium-Rich Compound | Melting Point of Aluminium-Rich Compound                                         | Eutectic with Aluminium-Rich Compound | Solubility in Aluminium-Rich Compound | Compound Formed                                                                                                                                          |
|-----------------------------------------------------------------------------------------------|-------------------------------------------------------|----------------------------------------|----------------------------------------------------------------------------------|---------------------------------------|---------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------|
| Aluminium                                                                                     |                                                       |                                        | Deg. C.                                                                          | Deg. C.                               | Per Cent                              |                                                                                                                                                          |
| Antimony                                                                                      | Mathewa, Campbell and Mathewa (387), Tannmann (415)   | SbAl                                   | 1065                                                                             | 655                                   | .....                                 | Nearly zero (1) SbAl                                                                                                                                     |
| Calcium                                                                                       | Donaki (364)                                          | CaAl <sub>2</sub>                      | .....                                                                            | 610                                   | 5.6                                   | Nearly zero (1) CaAl <sub>2</sub>                                                                                                                        |
| Chromium                                                                                      | Hindricks (371)                                       | AlCr <sub>2</sub> (?)                  | .....                                                                            | 643                                   | 1 (?)                                 | Nearly zero (1) AlCr <sub>2</sub> (?)                                                                                                                    |
| Cobalt                                                                                        | Gwyer (368)                                           | Co <sub>2</sub> Al <sub>13</sub>       | (2)                                                                              | 630                                   | 5                                     | Nearly zero (1) CoAl, Co <sub>2</sub> Al <sub>5</sub> , Co <sub>2</sub> Al <sub>13</sub> (?)                                                             |
| Copper                                                                                        | Gwyer (378), Carpenter & Edwards (380), Curry (382)   | Al <sub>2</sub> Cu                     | (2)                                                                              | 545                                   | 32                                    | About 4 Cu <sub>2</sub> Al, CuAl <sub>2</sub>                                                                                                            |
| Gold                                                                                          | Haycock and Neville (359, 360)                        | Al <sub>2</sub> Au                     | .....                                                                            | 647                                   | 1.1                                   | Nearly zero (1) Al <sub>2</sub> Au <sub>4</sub> , Al <sub>2</sub> Au <sub>10</sub> , Al <sub>2</sub> Au <sub>12</sub> , Al <sub>2</sub> Au <sub>14</sub> |
| Iron                                                                                          | Gwyer (378)                                           | FeAl <sub>2</sub>                      | 1150                                                                             | 649                                   | 1 (?)                                 | Nearly zero (1) FeAl <sub>2</sub>                                                                                                                        |
| Magnesium                                                                                     | Grube (402)                                           | Mg <sub>2</sub> Al <sub>3</sub>        | 463                                                                              | 453                                   | 35                                    | About 1 Mg <sub>2</sub> Al <sub>3</sub>                                                                                                                  |
| Manganese                                                                                     | Hindricks (405)                                       | Al <sub>2</sub> Mn                     | .....                                                                            | 649                                   | 3 (?)                                 | Nearly zero (1) AlMn <sub>2</sub> (?)                                                                                                                    |
| Nickel                                                                                        | Gwyer (409)                                           | Ni <sub>2</sub> Al <sub>3</sub>        | (2)                                                                              | 630                                   | 6                                     | Nearly zero (1) NiAl, NiAl <sub>2</sub> , NiAl <sub>3</sub>                                                                                              |
| Silver                                                                                        | Gautier, Potrenko (357)                               | Ag <sub>2</sub> Al                     | .....                                                                            | 567                                   | 30                                    | Nearly zero (1) Ag <sub>2</sub> Al, Ag <sub>3</sub> Al                                                                                                   |
| Zinc                                                                                          | Lorenz & Plumbridge (436), Rosenhain & Archbutt (438) | Al <sub>2</sub> Zn <sub>5</sub>        | (2)                                                                              | 380 (3)                               | 95 (3)                                | 20-40 Al <sub>2</sub> Zn <sub>5</sub>                                                                                                                    |
| Cerium                                                                                        | Vogel (366)                                           | CeAl <sub>3</sub>                      | .....                                                                            | 638                                   | 10                                    | Not known Ce <sub>2</sub> Al, Ce <sub>3</sub> Al, CeAl, CeAl <sub>2</sub> , CeAl <sub>3</sub> , CeAl <sub>4</sub>                                        |
| Platinum                                                                                      | Chourigine (413, 414)                                 | PbAl <sub>3</sub>                      | .....                                                                            | 639                                   | 9                                     | ..... PbAl <sub>3</sub>                                                                                                                                  |
| Vanadium                                                                                      | Czako (431)                                           | VAl <sub>3</sub>                       | .....                                                                            | .....                                 | .....                                 | .....                                                                                                                                                    |
| (1) Not determined.                                                                           |                                                       |                                        |                                                                                  |                                       |                                       |                                                                                                                                                          |
| (2) Decomposes before fusing.                                                                 |                                                       |                                        |                                                                                  |                                       |                                       |                                                                                                                                                          |
| (3) Eutectic of zinc-Zn, Al <sub>2</sub> .                                                    |                                                       |                                        |                                                                                  |                                       |                                       |                                                                                                                                                          |
| (4) Latest references are given, but not all, as earlier ones are always noted in the former. |                                                       |                                        |                                                                                  |                                       |                                       |                                                                                                                                                          |
| (B) The metals are not miscible or only slightly so in the liquid state.                      |                                                       |                                        |                                                                                  |                                       |                                       |                                                                                                                                                          |
| Alloy System                                                                                  | References                                            | Per Cent                               | References                                                                       | Per Cent                              | References                            | Per Cent                                                                                                                                                 |
| Aluminium                                                                                     |                                                       |                                        |                                                                                  |                                       |                                       |                                                                                                                                                          |
| and:                                                                                          |                                                       |                                        |                                                                                  |                                       |                                       |                                                                                                                                                          |
| Bismuth                                                                                       | Gwyer (362)                                           | 10                                     | Roberts (417), Fraenkel (420)                                                    | 10                                    |                                       |                                                                                                                                                          |
| Cadmium                                                                                       | Gwyer (365)                                           | 10                                     | Gwyer (424), Shepherd (425), Campbell & Mathewa (428), Lorenz & Plumbridge (423) | 10                                    |                                       |                                                                                                                                                          |
| Lead                                                                                          | Gwyer (411)                                           | 2.1                                    |                                                                                  |                                       |                                       |                                                                                                                                                          |
| Potassium                                                                                     | Mathewson (393)                                       |                                        |                                                                                  |                                       |                                       |                                                                                                                                                          |
| Sodium                                                                                        | Mathewson (393)                                       |                                        |                                                                                  |                                       |                                       |                                                                                                                                                          |
| (C) The metals form a simple eutectiferous series.                                            |                                                       |                                        |                                                                                  |                                       |                                       |                                                                                                                                                          |
| Alloy System                                                                                  | References                                            | Per Cent                               | References                                                                       | Per Cent                              | References                            | Per Cent                                                                                                                                                 |
| Aluminium and:                                                                                |                                                       |                                        |                                                                                  |                                       |                                       |                                                                                                                                                          |
| Autectic                                                                                      |                                                       |                                        |                                                                                  |                                       |                                       |                                                                                                                                                          |
| Silicon                                                                                       | 576                                                   | 10                                     | Roberts (417), Fraenkel (420)                                                    | 10                                    |                                       |                                                                                                                                                          |
| Tin                                                                                           | 229.1                                                 | 2.1                                    | Gwyer (424), Shepherd (425), Campbell & Mathewa (428), Lorenz & Plumbridge (423) | 2.1                                   |                                       |                                                                                                                                                          |
| (D) Ternary Systems.                                                                          |                                                       |                                        |                                                                                  |                                       |                                       |                                                                                                                                                          |
| System                                                                                        | References                                            | Per Cent                               | References                                                                       | Per Cent                              | References                            | Per Cent                                                                                                                                                 |
| Al-Mg-Zn                                                                                      | Eger (462)                                            |                                        |                                                                                  |                                       |                                       |                                                                                                                                                          |
| Al-Cu-Zn                                                                                      | Carpenter and Edwards (465)                           |                                        |                                                                                  |                                       |                                       |                                                                                                                                                          |
| Al-Mn-Cu                                                                                      | Rosenhain and Lantieri (466)                          |                                        |                                                                                  |                                       |                                       |                                                                                                                                                          |
| Al-Cu-Sn                                                                                      | Andrews and Edwards (467)                             |                                        |                                                                                  |                                       |                                       |                                                                                                                                                          |



sults of these investigations are summarized in a statement of the alloys which are in commercial use today. The industry has taken and developed further those alloys which the results of investigation have shown to be promising from the standpoint either of mechanical strength or of other special properties.

For casting alloys the aluminium-zinc-copper or the aluminium-copper alloys have been most largely used, whereas for forging and rolling, the alloy, duralumin, has hitherto held its own in the commercial field. The only serious rival which duralumin has today as a rolling and forging alloy of maximum mechanical

TABLE XIV.  
TESTS OF ROLLED BINARY ALUMINIUM ALLOYS  
(Schirmerstein—341)

| Per Cent Composition | Tensile Strength, Lb. per Sq. in. | Elongation in 2 in. | Per Cent Hardness, B.H.N. | Remarks                                                                                                                                                                                                                                                                                                                                                                                            | Per Cent Composition | Tensile Strength, Lb. per Sq. in. | Elongation in 2 in. | Per Cent Hardness, B.H.N. | Remarks                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |    |
|----------------------|-----------------------------------|---------------------|---------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------|-----------------------------------|---------------------|---------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----|
| <b>Antimony</b>      |                                   |                     |                           |                                                                                                                                                                                                                                                                                                                                                                                                    |                      |                                   |                     |                           |                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |    |
| 0 0                  | 14,900                            | 34                  | 29                        | Rolled at 450-500 deg. C., 8 m. per min. to 1.4 mm. It is only possible to roll these alloys up to 11 per cent of antimony; even at 8 per cent a certain amount of tearing and cracking takes place. Antimony is seen to be an undesirable addition to aluminium.                                                                                                                                  | 0 0                  | 13,500                            | 41                  | 26                        | Rolled at 500 deg. C., 40 m. per min. to 1.4 mm. These alloys can be rolled up to 5 per cent of molybdenum. The series shows, however, no improvement in properties.                                                                                                                                                                                                                                                                                                     |    |
| 0 4                  | 14,600                            | 37                  | ..                        |                                                                                                                                                                                                                                                                                                                                                                                                    | 0 4                  | 15,900                            | 36                  | 33                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | .. |
| 1 0                  | 14,600                            | 40                  | 29                        |                                                                                                                                                                                                                                                                                                                                                                                                    | 0 7                  | 16,800                            | 34                  | ..                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | .. |
| 2 0                  | 14,600                            | 38                  | ..                        |                                                                                                                                                                                                                                                                                                                                                                                                    | 0 9                  | 16,800                            | 33                  | 34                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | .. |
| 3 2                  | 14,800                            | 36                  | 30                        |                                                                                                                                                                                                                                                                                                                                                                                                    | 1 2                  | 16,400                            | 29                  | 33                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | .. |
| 4 5                  | 14,900                            | 32                  | ..                        |                                                                                                                                                                                                                                                                                                                                                                                                    | 1 5                  | 16,500                            | 29                  | ..                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | .. |
| 6 0                  | 14,900                            | 29                  | ..                        |                                                                                                                                                                                                                                                                                                                                                                                                    | 3 7                  | 16,900                            | 16                  | 42                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | .. |
| 8 0                  | 15,400                            | 23                  | 27                        |                                                                                                                                                                                                                                                                                                                                                                                                    | 4 9                  | 17,200                            | 16                  | ..                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | .. |
| 10 5                 | 14,900                            | 17                  | ..                        |                                                                                                                                                                                                                                                                                                                                                                                                    | 0 0                  | 13,500                            | 34                  | 29                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | .. |
| <b>Bismuth</b>       |                                   |                     |                           |                                                                                                                                                                                                                                                                                                                                                                                                    |                      |                                   |                     |                           |                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |    |
| 0 0                  | 16,300                            | 32                  | ..                        | 0 6                                                                                                                                                                                                                                                                                                                                                                                                | 15,900               | 33                                | 34                  | ..                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |    |
| 0 4                  | 16,600                            | 33                  | ..                        | 1 0                                                                                                                                                                                                                                                                                                                                                                                                | 16,300               | 32                                | ..                  | ..                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |    |
| 1 2                  | 17,800                            | 31                  | ..                        | 1 9                                                                                                                                                                                                                                                                                                                                                                                                | 18,100               | 29                                | ..                  | ..                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |    |
| 3 0                  | 16,500                            | 30                  | ..                        | 3 1                                                                                                                                                                                                                                                                                                                                                                                                | 20,900               | 27                                | 44                  | ..                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |    |
| 4 8                  | 15,800                            | 30                  | ..                        | 4 5                                                                                                                                                                                                                                                                                                                                                                                                | 21,400               | 22                                | 45                  | ..                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |    |
| 0 0                  | 16,300                            | 32                  | ..                        | 8 1                                                                                                                                                                                                                                                                                                                                                                                                | 21,200               | 16                                | 47                  | ..                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |    |
| 0 4                  | 16,600                            | 33                  | ..                        | 10 3                                                                                                                                                                                                                                                                                                                                                                                               | 23,500               | 8                                 | 53                  | ..                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |    |
| <b>Cadmium</b>       |                                   |                     |                           |                                                                                                                                                                                                                                                                                                                                                                                                    |                      |                                   |                     |                           |                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |    |
| 0 0                  | 16,300                            | 32                  | 31                        | Rolled at 100 to 150 deg. C., 8 m. per min. to 1.4 mm. These alloys may be rolled up to 6 per cent or more. Results show that there is no advantage in the addition of cadmium.                                                                                                                                                                                                                    | 0 5                  | 15,300                            | 41                  | 26                        | Rolled at 450 to 500 deg. C., 40 m. per min. to 1.4 mm. These alloys may be rolled up to 20 per cent of silicon. The author finds that the resistance to atmospheric corrosion of this series is fairly good in spite of the fact that it has been claimed that silicon causes a great corrodibility in aluminium. The author believes that an addition of silicon is of advantage and that from 5 to 7 per cent of silicon may be added for rolling and forging alloys. |    |
| 0 4                  | 16,500                            | 33                  | ..                        |                                                                                                                                                                                                                                                                                                                                                                                                    | 1 7                  | 14,900                            | 41                  | ..                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | .. |
| 1 3                  | 16,300                            | 35                  | 40                        |                                                                                                                                                                                                                                                                                                                                                                                                    | 1 7                  | 15,900                            | 40                  | 31                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | .. |
| 1 8                  | 16,300                            | 36                  | ..                        |                                                                                                                                                                                                                                                                                                                                                                                                    | 4 9                  | 17,800                            | 33                  | 38                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | .. |
| 2 7                  | 16,500                            | 34                  | 42                        |                                                                                                                                                                                                                                                                                                                                                                                                    | 7 0                  | 19,300                            | 32                  | 38                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | .. |
| 4 0                  | 16,500                            | 32                  | ..                        |                                                                                                                                                                                                                                                                                                                                                                                                    | 9 6                  | 21,600                            | 27                  | 43                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | .. |
| 6 0                  | 16,600                            | 32                  | 40                        |                                                                                                                                                                                                                                                                                                                                                                                                    | 12 4                 | 23,800                            | 23                  | 47                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | .. |
| 0 0                  | 13,500                            | 41                  | 26                        |                                                                                                                                                                                                                                                                                                                                                                                                    | 15 1                 | 22,300                            | 17                  | 48                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | .. |
| 0 4                  | 13,700                            | 46                  | 37                        |                                                                                                                                                                                                                                                                                                                                                                                                    | 18 8                 | 23,500                            | 11                  | ..                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | .. |
| <b>Chromium</b>      |                                   |                     |                           |                                                                                                                                                                                                                                                                                                                                                                                                    |                      |                                   |                     |                           |                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |    |
| 0 0                  | 13,500                            | 41                  | 26                        | Rolled at 500 deg. C., 8 m. per min. to 1.4 mm. Chromium can be added to aluminium in amounts as great as 5 or 6 per cent and can be rolled at 500 deg. up to a content of 4 per cent. Chromium does not seem to offer any advantages as an addition to aluminium although it might be used to harden it in amounts up to 1 per cent.                                                              | 0 0                  | 13,500                            | 41                  | 26                        | Rolled at 500 deg. C., 40 m. per min. to 1.4 mm. Only a few alloys were made of this series. Results show that tantalum cannot be considered as a technical utilizable constituent for aluminium alloys.                                                                                                                                                                                                                                                                 |    |
| 0 4                  | 17,600                            | 26                  | 37                        |                                                                                                                                                                                                                                                                                                                                                                                                    | 0 3                  | 14,200                            | 38                  | ..                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | .. |
| 0 6                  | 21,200                            | 17                  | 47                        |                                                                                                                                                                                                                                                                                                                                                                                                    | 0 8                  | 15,100                            | 38                  | 30                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | .. |
| 0 9                  | 22,100                            | 17                  | 47                        |                                                                                                                                                                                                                                                                                                                                                                                                    | 1 5                  | 14,600                            | 38                  | 28                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | .. |
| 1 4                  | 19,600                            | 21                  | ..                        |                                                                                                                                                                                                                                                                                                                                                                                                    | 2 2                  | 14,600                            | 39                  | 28                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | .. |
| 1 9                  | 17,500                            | 22                  | 38                        |                                                                                                                                                                                                                                                                                                                                                                                                    | 3 5                  | 14,200                            | 39                  | ..                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | .. |
| 2 6                  | 17,600                            | 21                  | ..                        |                                                                                                                                                                                                                                                                                                                                                                                                    | 0 0                  | 15,500                            | 37                  | 31                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | .. |
| 3 7                  | 18,300                            | 19                  | 42                        |                                                                                                                                                                                                                                                                                                                                                                                                    | 1 0                  | 15,200                            | 31                  | ..                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | .. |
| 4 5                  | 18,900                            | 11                  | ..                        |                                                                                                                                                                                                                                                                                                                                                                                                    | 1 9                  | 15,300                            | 29                  | 31                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | .. |
| <b>Cobalt</b>        |                                   |                     |                           |                                                                                                                                                                                                                                                                                                                                                                                                    |                      |                                   |                     |                           |                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |    |
| 0 0                  | 14,900                            | 34                  | 29                        | Rolled at 450 to 500 deg. C., 8 m. per min. to 1.4 mm. These alloys may be rolled up to approximately 11 per cent of cobalt. Four per cent of cobalt is about the most favorable composition.                                                                                                                                                                                                      | 3 0                  | 15,600                            | 27                  | ..                        | Rolled cold, 40 m. per min. to 1.4 mm. Tin diminishes the ease of working aluminium at higher temperatures; it is possible to roll these alloys only cold. Tin is an undesirable addition to aluminium.                                                                                                                                                                                                                                                                  |    |
| 0 6                  | 15,500                            | 35                  | 32                        |                                                                                                                                                                                                                                                                                                                                                                                                    | 4 8                  | 15,600                            | 27                  | ..                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | .. |
| 1 6                  | 17,100                            | 28                  | ..                        |                                                                                                                                                                                                                                                                                                                                                                                                    | 6 4                  | 16,100                            | 26                  | 32                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | .. |
| 2 3                  | 17,500                            | 25                  | 27                        |                                                                                                                                                                                                                                                                                                                                                                                                    | 8 2                  | 16,600                            | 20                  | ..                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | .. |
| 3 5                  | 18,300                            | 21                  | 47                        |                                                                                                                                                                                                                                                                                                                                                                                                    | 10 3                 | 17,400                            | 17                  | ..                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | .. |
| 5 5                  | 22,100                            | 18                  | 50                        |                                                                                                                                                                                                                                                                                                                                                                                                    | 12 4                 | 18,500                            | 15                  | 31                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | .. |
| 7 5                  | 23,600                            | 14                  | 50                        |                                                                                                                                                                                                                                                                                                                                                                                                    | 0 0                  | 13,500                            | 41                  | 26                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | .. |
| 9 4                  | 23,500                            | 11                  | 51                        |                                                                                                                                                                                                                                                                                                                                                                                                    | 0 4                  | 15,600                            | 31                  | 34                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | .. |
| 10 5                 | 24,200                            | 11                  | ..                        |                                                                                                                                                                                                                                                                                                                                                                                                    | 1 2                  | 16,100                            | 31                  | ..                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | .. |
| <b>Copper</b>        |                                   |                     |                           |                                                                                                                                                                                                                                                                                                                                                                                                    |                      |                                   |                     |                           |                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |    |
| 0 0                  | 14,900                            | 34                  | 29                        | Rolled at 400 to 450 deg. C., 8 m. per min. to 1.4 mm. These alloys may be rolled hot up to 12 per cent of copper. The author considers 3 to 4 per cent of copper to be the most advantageous composition.                                                                                                                                                                                         | 1 6                  | 16,400                            | 30                  | 33                        | Rolled at 500 deg. C., 40 m. per min. to 1.4 mm. These two metals are quite readily alloyed, although a high pouring temperature is necessary. Up to 6 per cent of titanium the alloys of this series are readily rolled. The physical properties are not such that the alloys may be attributed any technical importance.                                                                                                                                               |    |
| 0 5                  | 15,500                            | 34                  | 33                        |                                                                                                                                                                                                                                                                                                                                                                                                    | 2 1                  | 16,800                            | 27                  | 35                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | .. |
| 1 0                  | 21,900                            | 26                  | 41                        |                                                                                                                                                                                                                                                                                                                                                                                                    | 3 1                  | 17,400                            | 27                  | ..                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | .. |
| 2 1                  | 24,300                            | 23                  | 46                        |                                                                                                                                                                                                                                                                                                                                                                                                    | 4 5                  | 18,500                            | 19                  | ..                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | .. |
| 3 5                  | 25,600                            | 22                  | 48                        |                                                                                                                                                                                                                                                                                                                                                                                                    | 8 2                  | 20,100                            | 16                  | 42                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | .. |
| 5 1                  | 25,300                            | 21                  | 49                        |                                                                                                                                                                                                                                                                                                                                                                                                    | 0 0                  | 13,500                            | 41                  | 26                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | .. |
| 7 1                  | 25,600                            | 21                  | 49                        |                                                                                                                                                                                                                                                                                                                                                                                                    | 0 4                  | 15,600                            | 31                  | 34                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | .. |
| 8 9                  | 26,600                            | 19                  | 52                        |                                                                                                                                                                                                                                                                                                                                                                                                    | 1 2                  | 16,100                            | 31                  | ..                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | .. |
| 11 0                 | 27,700                            | 16                  | ..                        |                                                                                                                                                                                                                                                                                                                                                                                                    | 1 6                  | 16,400                            | 30                  | 33                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | .. |
| <b>Iron</b>          |                                   |                     |                           |                                                                                                                                                                                                                                                                                                                                                                                                    |                      |                                   |                     |                           |                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |    |
| 0 9                  | 14,900                            | 34                  | 29                        | Rolled at 450 to 500 deg. C., 8 m. per min. to 1.4 mm. These alloys may be rolled up to a composition of 12 per cent although it presents some difficulty to most of the alloys. The author considers that although the iron-aluminum alloys do not show properties which would make them of any utility, it is shown by his work that 2 or 3 per cent of iron in aluminium alloys is not harmful. | 2 1                  | 16,800                            | 27                  | 35                        | Rolled at 500 deg. C., 40 m. per min. to 1.4 mm. The ease of rolling hot is not unfavorably affected by tungsten, which can be added to aluminium alloy rolled up to 6 per cent. Tungsten does not seem to offer any advantages as an addition to aluminium.                                                                                                                                                                                                             |    |
| 1 3                  | 15,500                            | 36                  | ..                        |                                                                                                                                                                                                                                                                                                                                                                                                    | 3 1                  | 17,400                            | 27                  | ..                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | .. |
| 1 8                  | 16,300                            | 33                  | 33                        |                                                                                                                                                                                                                                                                                                                                                                                                    | 4 5                  | 18,500                            | 19                  | ..                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | .. |
| 2 7                  | 17,500                            | 31                  | 37                        |                                                                                                                                                                                                                                                                                                                                                                                                    | 8 2                  | 20,100                            | 16                  | 42                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | .. |
| 3 7                  | 17,900                            | 29                  | 37                        |                                                                                                                                                                                                                                                                                                                                                                                                    | 0 0                  | 13,500                            | 41                  | 26                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | .. |
| 5 0                  | 17,800                            | 25                  | ..                        |                                                                                                                                                                                                                                                                                                                                                                                                    | 0 3                  | 14,200                            | 42                  | 29                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | .. |
| 6 8                  | 17,600                            | 18                  | 38                        |                                                                                                                                                                                                                                                                                                                                                                                                    | 1 1                  | 15,500                            | 40                  | 32                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | .. |
| 8 8                  | 17,100                            | 12                  | ..                        |                                                                                                                                                                                                                                                                                                                                                                                                    | 1 5                  | 15,400                            | 37                  | 34                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | .. |
| 11 1                 | 16,800                            | 8                   | 44                        |                                                                                                                                                                                                                                                                                                                                                                                                    | 3 5                  | 15,500                            | 33                  | 34                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | .. |
| <b>Lead</b>          |                                   |                     |                           |                                                                                                                                                                                                                                                                                                                                                                                                    |                      |                                   |                     |                           |                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |    |
| 12 5                 | 16,200                            | 7                   | ..                        | 6 0                                                                                                                                                                                                                                                                                                                                                                                                | 15,400               | 32                                | 33                  | ..                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |    |
| 0 0                  | 14,900                            | 34                  | ..                        | Rolled at 300 deg. C., 8 m. per min. to 1.4 mm. These alloys can be rolled hot quite readily up to 4 per cent or more; the addition of lead in small amounts is not of any value, at the same time it has no marked ill effect upon the properties.                                                                                                                                                | 0 0                  | 13,500                            | 41                  | 26                        | Rolled at 350 to 400 deg. C., 8 m. per min. to 1.4 mm. Can be rolled up to 30 per cent; most suitable are from 12-14 per cent. These alloys can be rolled out up to 30 per cent of zinc. The author considers that the most suitable of them are those with from 12 to 14 per cent of zinc.                                                                                                                                                                              |    |
| 0 4                  | 14,200                            | 40                  | ..                        |                                                                                                                                                                                                                                                                                                                                                                                                    | 0 4                  | 15,300                            | 41                  | 26                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | .. |
| 0 9                  | 14,100                            | 37                  | ..                        |                                                                                                                                                                                                                                                                                                                                                                                                    | 0 8                  | 16,100                            | 36                  | 33                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | .. |
| 1 5                  | 14,400                            | 35                  | ..                        |                                                                                                                                                                                                                                                                                                                                                                                                    | 1 2                  | 16,800                            | 34                  | 34                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | .. |
| 2 5                  | 14,500                            | 34                  | ..                        |                                                                                                                                                                                                                                                                                                                                                                                                    | 2 0                  | 17,800                            | 28                  | 38                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | .. |
| 4 0                  | 14,200                            | 34                  | ..                        |                                                                                                                                                                                                                                                                                                                                                                                                    | 3 7                  | 17,800                            | 27                  | 39                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | .. |
| 0 0                  | 14,900                            | 34                  | 29                        |                                                                                                                                                                                                                                                                                                                                                                                                    | 0 0                  | 14,900                            | 34                  | 29                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | .. |
| 0 3                  | 15,500                            | 34                  | 33                        |                                                                                                                                                                                                                                                                                                                                                                                                    | 0 6                  | 15,900                            | 32                  | ..                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | .. |
| 0 6                  | 16,200                            | 33                  | 33                        |                                                                                                                                                                                                                                                                                                                                                                                                    | 1 0                  | 16,300                            | 32                  | ..                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | .. |
| <b>Magnesium</b>     |                                   |                     |                           |                                                                                                                                                                                                                                                                                                                                                                                                    |                      |                                   |                     |                           |                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |    |
| 0 0                  | 14,900                            | 34                  | 29                        | Rolled at 450 deg. C., 8 m. per min. to 1.4 mm. It is possible to roll these alloys up to approximately 6 per cent. Above that the alloys crack and splinter. The author does not consider that magnesium is a valuable addition to aluminium for a rolling alloy.                                                                                                                                 | 1 3                  | 17,900                            | 24                  | ..                        | Rolled at 500 deg. C., 40 m. per min. to 1.4 mm. Manganese-aluminum alloys may be rolled to approximately 5 per cent without much tearing. The author considers that 1 or 2 per cent of manganese might be added with advantage to aluminium.                                                                                                                                                                                                                            |    |
| 0 3                  | 15,500                            | 34                  | 33                        |                                                                                                                                                                                                                                                                                                                                                                                                    | 3 0                  | 17,800                            | 27                  | ..                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | .. |
| 0 6                  | 16,200                            | 33                  | 33                        |                                                                                                                                                                                                                                                                                                                                                                                                    | 4 0                  | 17,800                            | 27                  | ..                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | .. |
| 1 2                  | 15,900                            | 33                  | 33                        |                                                                                                                                                                                                                                                                                                                                                                                                    | 7 8                  | 20,200                            | 28                  | ..                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | .. |
| 1 6                  | 16,200                            | 33                  | 34                        |                                                                                                                                                                                                                                                                                                                                                                                                    | 10 3                 | 24,200                            | 32                  | 42                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | .. |
| 2 6                  | 21,700                            | 28                  | 42                        |                                                                                                                                                                                                                                                                                                                                                                                                    | 12 7                 | 25,600                            | 33                  | 60                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | .. |
| 4 0                  | 30,000                            | 22                  | 54                        |                                                                                                                                                                                                                                                                                                                                                                                                    | 16 0                 | 25,600                            | 26                  | 60                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | .. |
| 6 0                  | 41,800                            | 21                  | 69                        |                                                                                                                                                                                                                                                                                                                                                                                                    | 18 5                 | 41,000                            | 20                  | ..                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | .. |
| 0 0                  | 13,500                            | 41                  | 26                        |                                                                                                                                                                                                                                                                                                                                                                                                    | 23 0                 | 50,100                            | 17                  | 124                       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | .. |
| 0 4                  | 14,800                            | 36                  | 31                        | 25 3                                                                                                                                                                                                                                                                                                                                                                                               | 53,500               | 15                                | 124                 | ..                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |    |
| <b>Manganese</b>     |                                   |                     |                           |                                                                                                                                                                                                                                                                                                                                                                                                    |                      |                                   |                     |                           |                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |    |
| 0 6                  | 15,300                            | 33                  | 31                        | Rolled at 500 deg. C., 40 m. per min. to 1.4 mm. Manganese-aluminum alloys may be rolled to approximately 5 per cent without much tearing. The author considers that 1 or 2 per cent of manganese might be added with advantage to aluminium.                                                                                                                                                      | 0 0                  | 13,500                            | 41                  | 26                        | Rolled at 500 deg. C., 40 m. per min. to 1.4 mm. Zirconium acts much as does titanium as an alloy constituent of aluminium; alloys may be rolled up to 6 per cent of zirconium; do not show any remarkably good physical properties, however.                                                                                                                                                                                                                            |    |
| 0 8                  | 16,200                            | 34                  | ..                        |                                                                                                                                                                                                                                                                                                                                                                                                    | 0 4                  | 15,100                            | 34                  | 31                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | .. |
| 1 3                  | 17,100                            | 28                  | ..                        |                                                                                                                                                                                                                                                                                                                                                                                                    | 0 8                  | 15,200                            | 34                  | 31                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | .. |
| 2 4                  | 18,200                            | 22                  | 39                        |                                                                                                                                                                                                                                                                                                                                                                                                    | 1 2                  | 15,100                            | 32                  | ..                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | .. |
| 3 2                  | 19,100                            | 19                  | ..                        |                                                                                                                                                                                                                                                                                                                                                                                                    | 1 6                  | 15,400                            | 34                  | 31                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | .. |
| 4 8                  | 19,500                            | 18                  | 46                        |                                                                                                                                                                                                                                                                                                                                                                                                    | 2 4                  | 15,800                            | 34                  | 33                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | .. |
| 0 0                  | 14,900                            | 34                  | 29                        |                                                                                                                                                                                                                                                                                                                                                                                                    | 3 2                  | 16,100                            | 33                  | 33                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | .. |
| 0 6                  | 15,300                            | 33                  | 31                        |                                                                                                                                                                                                                                                                                                                                                                                                    | 4 5                  | 16,900                            | 28                  | ..                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | .. |
| 0 8                  | 16,200                            | 34                  | ..                        |                                                                                                                                                                                                                                                                                                                                                                                                    | 6 0                  | 17,800                            | 25                  | 37                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | .. |
| <b>Zinc</b>          |                                   |                     |                           |                                                                                                                                                                                                                                                                                                                                                                                                    |                      |                                   |                     |                           |                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |    |
| 0 0                  | 14,900                            | 34                  | 29                        | Rolled at 300 deg. C., 8 m. per min. to 1.4 mm. These alloys can be rolled hot quite readily up to 4 per cent or more; the addition of lead in small amounts is not of any value, at the same time it has no marked ill effect upon the properties.                                                                                                                                                | 0 0                  | 13,500                            | 41                  | 26                        | Rolled at 500 deg. C., 40 m. per min. to 1.4 mm. Zirconium acts much as does titanium as an alloy constituent of aluminium; alloys may be rolled up to 6 per cent of zirconium; do not show any remarkably good physical properties, however.                                                                                                                                                                                                                            |    |
| 0 4                  | 14,200                            | 40                  | ..                        |                                                                                                                                                                                                                                                                                                                                                                                                    | 0 4                  | 15,100                            | 34                  | 31                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | .. |
| 0 9                  | 14,100                            | 37                  | ..                        |                                                                                                                                                                                                                                                                                                                                                                                                    | 0 8                  | 15,200                            | 34                  | 31                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | .. |
| 1 5                  | 14,400                            | 35                  | ..                        |                                                                                                                                                                                                                                                                                                                                                                                                    | 1 2                  | 15,100                            | 32                  | ..                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | .. |
| 2 5                  | 14,500                            | 34                  | ..                        |                                                                                                                                                                                                                                                                                                                                                                                                    | 1 6                  | 15,400                            | 34                  | 31                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | .. |
| 4 0                  | 14,200                            | 34                  | ..                        |                                                                                                                                                                                                                                                                                                                                                                                                    | 2 4                  | 15,800                            | 34                  | 33                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | .. |
| 0 0                  | 14,900                            | 34                  | 29                        |                                                                                                                                                                                                                                                                                                                                                                                                    | 3 2                  | 16,100                            | 33                  | 33                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | .. |
| 0 6                  | 15,300                            | 33                  | 31                        |                                                                                                                                                                                                                                                                                                                                                                                                    | 4 5                  | 16,900                            | 28                  | ..                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | .. |
| 0 8                  | 16,200                            | 34                  | ..                        |                                                                                                                                                                                                                                                                                                                                                                                                    | 6 0                  | 17,800                            | 25                  | 37                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | .. |

(\*) The Brinell hardness numeral was determined with a 2.5 mm. ball, using a pressure of 62.5 kg.

(1) The Brinell hardness numeral was determined with a 2.5 mm. ball, using a pressure of 62.5 kg.

strength is one of aluminium-zinc-copper developed by Rosenhain & Archbutt (438).

CASTING AND DIE-CASTING

Pure aluminium is but rarely used in the cast form, owing to its softness, high shrinkage and poor machining qualities. Its alloys, however, with zinc, copper or magnesium or combinations of these are excellent and give with proper care very good castings.

In general the casting practice for aluminium alloys follows that for brasses and bronzes. The alloys may preferably be melted in ordinary graphite crucibles in either oil, gas, coke or coal furnace; care should be taken not to overheat the metal as it then oxidizes, absorbs gases and may at higher temperatures absorb carbon and silicon from the crucible. Good practice favors keeping the temperature of the metal during melting practically at its melting point by the continuous addition of solid metal. Pouring should be done at the lowest temperature at which the metal will completely fill the mold; a temperature of 700 deg. C. or below is satisfactory. A low pouring temperature is particularly important for aluminium castings because of the high specific heat of the metal; if poured at a high temperature the metal in cooling heats the mold so hot that the rate of cooling is very slow; a coarse grain and weak metal result.

No flux should be used in melting down, and the surface should not be covered with carbon, as this may be included in the casting. Just before pouring, however, a small amount of zinc chloride may be added with advantage. This thoroughly cleans the surface, and prevents dross from entering the casting.

In molding castings to be poured in aluminium alloy, two characteristics of the material should be borne in mind:

(1) The metal and its alloys are quite brittle or "hot short" and fragile at temperatures just below the melting point, and (2) they are light. Consideration of the first fact means that the mold or cores should not be too hard. Ordinary green sand, not too fine, is to be recommended and hard ramming is to be avoided. A large percentage of bad castings are probably due to non-adherence to this principle.

The mold should be poured carefully and not too rapidly as the metal may otherwise fail to fill finer parts of the mold. The casting should be stripped as soon as set in order to prevent cracking. Owing to the lightness of the alloys chaplets are rarely needed in anchoring cores.

Commercial casting alloys may be obtained in ingot form and it is perhaps in general best to use such material. If the metals are alloyed in the foundry, a hardener should first be made containing from 10 to 50 per cent of the alloying constituent. In melting down, this hardener is first melted and the aluminium then added.

For the usual alloys 0.156 in. per foot is accepted as the pattern-maker's allowance for shrinkage; for aluminium, this is 0.203 in. per foot.

*Re-melting of aluminium.* The re-melting of scrap aluminium alloy in coarse form offers no particular difficulty, but that of borings and chips is extremely difficult (Gillett, 306) owing to the fact that each particle

is covered with an extremely tenacious coating of  $Al_2O_3$ , which effectually prevents its coalescence with its neighbor. Two remelting methods are in commercial use. In one, the chips are puddled in iron pots until a pasty mass of metal accumulates, which is then heated to a red heat until the dross and dirt rises, leaving clear metal. In the other the chips are mixed with a chloride and fluoride flux and melted in a crucible until the metal collects at the bottom. In a modification of this method (McKinney, 306) a low melting point chloride-fluoride flux is melted down in a crucible and the aluminium chips fed into it; the oxide is fluxed off of the chips which melt and collect at the bottom.

By these methods from 50 to 95 per cent recovery of metal is accomplished depending on the cleanliness of the chips. The metal should not be used except for unimportant castings of which the mechanical properties are not a prime consideration. Chips of magnalium, remelted by a method described by Coulson (395) gave much lower tensile strength than the original virgin metal and practically no ductility; the use of a deoxidizer such as metallic calcium caused a partial recovery of the former mechanical properties.

A more recent development has been the practice of briquetting light scrap of aluminium alloy (Stillman, 299). Tests made showed a shorter melting time and a lower melting loss for remelted briquetted "aluminium" than for remelted chips (8.1 per cent as against 13.8 per cent melting loss).

*Effect of casting section and of pouring temperature on mechanical properties.* Gillett (316) has investigated the most important question of the effect of pouring temperature on the mechanical properties of aluminium alloy castings.

A heat of No. 12 alloy (see below) was poured at 703 deg. C. into test bars of different sizes. His test results are given in Table XVI. It is seen that the greater the cross section of the casting, the lower the resulting tensile strength.

TABLE XVI.  
TENSILE PROPERTIES OF NO. 12 CASTING ALLOY  
(Gillett)

| A. Effect of casting section.<br>B. Effect of pouring temperature. |                      |                                      |  |
|--------------------------------------------------------------------|----------------------|--------------------------------------|--|
| Size, In.                                                          | Area of Section, In. | A.                                   |  |
|                                                                    |                      | Tensile Strength<br>Lb. per Sq. In.  |  |
| 0 9 × 0 4                                                          | 0 36                 | 16,000                               |  |
| 0 75 × 0 25                                                        | 0 186                | 18,000                               |  |
| 0 40 round                                                         | 0 125                | 20,000                               |  |
| 0 45 round                                                         | 0 157                | 19,000                               |  |
| 0 50 round                                                         | 0 196                | 18,000                               |  |
| 0 75 round                                                         | 0 440                | 16,000                               |  |
| 1 00 round                                                         | 1 00                 | 13,500                               |  |
|                                                                    |                      | B.                                   |  |
| Temperature,<br>Deg. F.                                            |                      | Tensile Strength,<br>Lb. per Sq. In. |  |
| 1200                                                               |                      | 20,000                               |  |
| 1250                                                               |                      | 19,500                               |  |
| 1300                                                               |                      | 14,200                               |  |
| 1350                                                               |                      | 18,500                               |  |
| 1400                                                               |                      | 18,000                               |  |
| 1450                                                               |                      | 17,800                               |  |
| 1500                                                               |                      | 17,500                               |  |
| 1550                                                               |                      | 17,000                               |  |
| 1600                                                               |                      | 16,000                               |  |

In part B of the same table are given Gillett's results on the effect of pouring No. 12 alloy into a (S.A.E.) cast-to-size test bar (0.5 in. in diameter) in green sand from different temperatures. The hardness decreases with increasing pouring temperature. Gillett tested the effect of pouring temperature on 53 alloys in all

(see Table XVII) and concludes that in general the alloys are weaker by approximately 20 per cent when poured hot (1550-1600 deg. F.) than when poured cold (1225-1250 deg. F.). His results on the different alloys are given in Table XVII. An exception was noted in

by Carpenter and Edwards (380) who give the following results for chill castings of an alloy of 4.63 per cent copper, balance aluminium:

| Pouring Temperature, Deg. C. | Tensile Strength, Lb. per sq. in. | Elongation in 2 in., Per Cent |
|------------------------------|-----------------------------------|-------------------------------|
| 650                          | 21,700                            | 8.5                           |
| 724                          | 15,700                            | 5.5                           |
| 707                          | 10,900                            | 3.0                           |

TABLE XVII.  
EFFECT OF POURING TEMPERATURE ON THE TENSILE STRENGTH OF LIGHT ALUMINIUM ALLOYS.  
Gillett (316)

(The bars were presumably poured in the S.A.E. cast-to-size test bar, in green sand. Aluminium containing 0.3 per cent Fe and 0.2 per cent Si was used in the preparation of the alloys.)

| Chemical Composition<br>Per Cent |                | Pouring<br>Temperature,<br>Deg. C. | Tensile<br>Strength<br>Lb. per<br>Sq. In. | Pouring<br>Temperature,<br>Deg. C. | Tensile<br>Strength,<br>Lb. Per<br>Sq. In. |
|----------------------------------|----------------|------------------------------------|-------------------------------------------|------------------------------------|--------------------------------------------|
| Pure Aluminium.....              |                | 760                                | 10,500                                    | 871                                | 8,000                                      |
| Copper-Aluminium Alloys:         |                |                                    |                                           |                                    |                                            |
| 2.....                           |                | 668                                | 13,800                                    | 871                                | 11,500                                     |
| 4.....                           |                | 668                                | 15,500                                    | 871                                | 13,000                                     |
| 6.....                           |                | 668                                | 17,600                                    | 871                                | 14,500                                     |
| 8.....                           |                | 668                                | 20,000                                    | 871                                | 15,500                                     |
| 10.....                          |                | 668                                | 21,000                                    | 871                                | 16,000                                     |
| 12.....                          |                | 668                                | 22,500                                    | 871                                | 17,500                                     |
| Zinc-Aluminium Alloys:           |                |                                    |                                           |                                    |                                            |
| 4.....                           |                | 668                                | 13,000                                    | 843                                | 10,000                                     |
| 8.....                           |                | 668                                | 17,000                                    | 843                                | 12,700                                     |
| 12.....                          |                | 668                                | 21,000                                    | 843                                | 14,000                                     |
| 16.....                          |                | 668                                | 24,000                                    | 843                                | 17,000                                     |
| 20.....                          |                | 668                                | 27,000                                    | 843                                | 20,000                                     |
| 24.....                          |                | 668                                | 30,000                                    | 843                                | 24,500                                     |
| 28.....                          |                | 668                                | 33,000                                    | 843                                | 27,500                                     |
| 32.....                          |                | 668                                | 35,000                                    | 843                                | 30,000                                     |
| 36.....                          |                | 668                                | 37,000                                    | 843                                | 33,000                                     |
| Copper-Zinc Aluminium Alloys:    |                |                                    |                                           |                                    |                                            |
| 8.0 0.25.....                    |                | 668                                | 20,000                                    | 843                                | 17,000                                     |
| 8.0 0.50.....                    |                | 668                                | 20,500                                    | 843                                | 17,000                                     |
| 7.5 1.0.....                     |                | 668                                | 18,000                                    | 843                                | 14,000                                     |
| 7.0 3.0.....                     |                | 668                                | 19,500                                    | 843                                | 15,500                                     |
| 7.0 9.0.....                     |                | 668                                | 25,000                                    | 843                                | 18,000                                     |
| 6.0 5.0.....                     |                | 668                                | 20,000                                    | 843                                | 15,000                                     |
| 6.0 10.0.....                    |                | 668                                | 24,000                                    | 843                                | 18,500                                     |
| 4.0 8.0.....                     |                | 668                                | 23,500                                    | 843                                | 17,000                                     |
| 4.0 15.0.....                    |                | 668                                | 32,000                                    | 843                                | 23,000                                     |
| 3.0 3.0.....                     |                | 668                                | 17,000                                    | 843                                | 13,000                                     |
| 3.0 6.0.....                     |                | 668                                | 19,000                                    | 843                                | 13,500                                     |
| 3.0 12.0.....                    |                | 668                                | 26,000                                    | 843                                | 18,500                                     |
| 3.0 15.0.....                    |                | 668                                | 28,500                                    | 843                                | 19,500                                     |
| 3.0 25.0.....                    |                | 668                                | 37,500                                    | 843                                | 29,500                                     |
| 2.5 19.0.....                    |                | 668                                | 33,000                                    | 843                                | 25,000                                     |
| 2.0 10.0.....                    |                | 668                                | 23,000                                    | 843                                | 15,500                                     |
| 2.0 22.0.....                    |                | 668                                | 36,000                                    | 843                                | 28,000                                     |
| 2.0 25.0.....                    |                | 668                                | 37,000                                    | 843                                | 33,000                                     |
| 1.75 30.....                     |                | 668                                | 42,000                                    | 843                                | 34,000                                     |
| 3.0 15.....                      | 0.50 Mn.       | 668                                | 30,000                                    | 843                                | 20,000                                     |
| Miscellaneous:                   |                |                                    |                                           |                                    |                                            |
| Cu.....                          | Mn 2.0         | 649                                | 19,000                                    | 843                                | 18,500                                     |
| 7.....                           | Mg 5           | 676                                | 20,500                                    | 760                                | 20,000                                     |
| 6.....                           |                | 649                                | 20,000                                    | 814                                | 17,500                                     |
| 4.....                           |                | 676                                | 19,000                                    | 814                                | 16,000                                     |
| 5.....                           |                | 676                                | 18,500                                    | 814                                | 16,500                                     |
| 6.....                           |                | 676                                | 16,000                                    | 814                                | 15,000                                     |
| 5.....                           |                | 657                                | 18,000                                    | 802                                | 15,750                                     |
| 6.....                           |                | 657                                | 16,800                                    | 814                                | 15,000                                     |
| 6.....                           |                | 703                                | 18,200                                    | 871                                | 14,500                                     |
| 8.....                           |                | 676                                | 19,000                                    | 814                                | 18,400                                     |
| 8.....                           |                | 649                                | 19,500                                    | 814                                | 15,900                                     |
| 8.....                           |                | 676                                | 20,000                                    | 814                                | 17,400                                     |
| 8.....                           |                | 676                                | 20,000                                    | 814                                | 18,500                                     |
| 8.....                           |                | 676                                | 18,600                                    | 814                                | 15,800                                     |
| 8.....                           |                | 676                                | 18,000                                    | 814                                | 14,000                                     |
| 4.....                           |                | 703                                | 19,700                                    | 843                                | 15,400                                     |
| 8.....                           |                | 676                                | 21,000                                    | 814                                | 18,000                                     |
| 8.....                           | 1.5 Fe Si 0.75 | 676                                |                                           |                                    |                                            |

the case of the 5 per cent magnalium and of the 2 per cent manganese alloy.

Rosenhain and Lantberry (466) have studied the effect of pouring temperature on the tensile properties of a chill cast aluminium-manganese-copper alloy No. 10 (see Table XIII) and find the following results:

| Pouring Temperature, Deg. C. | Tensile Strength, Lb. per Sq. In. | Elongation in 2 in., Per Cent |
|------------------------------|-----------------------------------|-------------------------------|
| 775-732                      | 12,900                            | 2                             |
| 687-675                      | 26,000                            | 8                             |
| 650                          | 25,300                            | 8                             |

Other tests have been made by Donaldson (438, discussion), who finds a falling off in tensile strength and elongation between 800 and 850 deg. C. for an alloy of 19 per cent zinc and 1 per cent copper:

| Pouring Temperature, Deg. C. | Tensile Strength, Lb. per Sq. In. | Elongation in 2 in., Per Cent |
|------------------------------|-----------------------------------|-------------------------------|
| 850                          | 20,400                            | 1.8                           |
| 800                          | 29,300                            | 4.0                           |
| 700                          | 22,000                            | 2.5                           |

and by Rosenhain (438, discussion), who contributes the following values for chill castings of an alloy of 20 per cent zinc and 1 per cent copper:

| Pouring Temperature, Deg. C. | Tensile Strength, Lb. per Sq. In. | Elongation in 2 in., Per Cent |
|------------------------------|-----------------------------------|-------------------------------|
| 850                          | 24,000                            | 2.5                           |
| 800                          | 30,800                            | 4.0                           |
| 750                          | 31,500                            | 3.0                           |
| 700                          | 31,700                            | 4.0                           |
| 650                          | 30,900                            | 5.0                           |

*Die-casting.* The term die-casting is rather vaguely understood to connote the casting of metal in metallic molds either with or without the mechanical application of pressure.

Die-castings may readily be made of aluminium alloys; the copper-aluminium alloys are particularly suitable for this class of work; aluminium-zinc alloys are difficult to handle because of their hot-shortness (Norton, 310). Norton describes the use by the Aluminium Castings Company of No. 12 alloy for this purpose. This metal gives castings which are of smooth surface, dense and dimensionally true within a very small margin ( $\pm .005$  in.). Mechanical properties for die-castings of No. 12 average:

|                                                                         | Sand Castings | Die Castings |
|-------------------------------------------------------------------------|---------------|--------------|
| Tensile strength, lb. per sq. in. ....                                  | 20,000        | 25,000       |
| Yield point (stress for 0.01 in. elong. in 2 in.), lb. per sq. in. .... | 13,000        | 13,000       |
| Elongation in 2 in., per cent .....                                     | 1.7           | 3.1          |
| Density .....                                                           | 2.84          | 2.87         |

Many articles are now die-cast in this alloy, such as parts of cash registers, typewriters, adding machines, and cooking utensils; pistons for gasoline motors are now produced of this alloy by die-casting.

Pack (302) describes an aluminium-copper alloy which is being commercially die-cast under pressure. The chief commercial difficulty with the die-casting of aluminium is the cracking or heat-checking of the iron or steel molds used; cracks appear in the mold after about 2,000 castings have been made in it.

*Composition and properties of casting alloys.* The physical properties of light casting alloys with which one is concerned are the tensile properties and the resistance to alternating stresses. The tensile properties of commercial alloys are of course well known; practically no data on the resistance to alternating stresses of these alloys are published although such data are of the utmost importance in view of the use of such castings for machine parts subject to vibration such as motor crank cases.

Some confusion exists with respect to the description of tensile properties; in this country a test specimen cast to size in green sand is usually used to determine these properties; this is usually 0.5 in. in diameter over the reduced section. In Great Britain a specimen cast to size in a chill is often used. Experience has shown that the tensile strength of chill test castings of light alloys will usually average from 3000 to 5000 lb. per sq. in. higher than for sand cast ones. This should always be borne in mind in comparing tests of these alloys.



Not only is the tensile strength of chill castings higher than that of sand castings, but also the elongation. In general any variation of casting condition which increases the tensile strength of a casting alloy increases also its ductility (elongation), and a double gain of hardness and toughness is thereby obtained.

Satisfactory results are obtained either on a cast-to-size test coupon, poured horizontally in sand with gate and riser, or with the Webbert type of cast-to-size coupon, cast in core sand and fed along its whole length by a gate and pouring head. The Naval Gun Factory (Washington) uses the latter form with a gate,  $\frac{3}{8}$  in. thick.

(1) "No. 12 alloy" (92 per cent aluminium, 8 per cent copper).

Melting range: 637 to 540 deg. C.

Shrinkage: 0.156 in. per foot.

Probably 95 per cent of all light alloy castings made in this country are of this alloy, probably the best known one to the trade. It is easily handled in the foundry, and does not suffer from hot shortness to the same degree that some of the other alloys do. This alloy can be depended on to give the following tensile properties when properly cast:

|                          |                        |
|--------------------------|------------------------|
| Tensile strength .....   | 18,000 lb. per sq. in. |
| Elongation in 2 in. .... | 1.5 per cent           |
| Specific gravity .....   | 2.89                   |

If the alloy is overheated or poured too hot, the tensile strength may be as low as 15,000 lb. per sq.in.; on the other hand with skillful handling in the foundry a greater hardness may be obtained, as high as tensile strengths of from 20,000 to 24,000 lb. per sq.in.

Jeffries<sup>1</sup> finds that this alloy when properly cast to give from 20,000 to 24,000 lb. per sq.in. tensile strength, will withstand 1,000,000 alternations of stress between 0 and 12,000 lb. per sq.in. tension without failure. The alloy is not as strong in impact test as No. 31 (see (3) below).

Broniewski (377) finds the electrical resistance of an alloy of this approximate composition to be 5.60 microhm-cm.

(2) Copper alloys containing from 8.5 to 14 per cent copper:

Melting range: 630—540 deg. C. (depending on copper content).

Shrinkage: 0.156 in. per foot.

These alloys are used for castings which are to be subjected to high temperatures such as manifolds, pistons, and also for castings to withstand pressure such as for pumps, etc.

The 8.5 to 11 per cent alloy is generally used for pistons and the 11 to 14 per cent alloy used for pressure castings.

These alloys will ordinarily give the following physical properties:

|                                 |                                  |
|---------------------------------|----------------------------------|
| Tensile strength .....          | 18,000 to 19,000 lb. per sq. in. |
| Elongation in 2 in. ....        | Usually less than 1 per cent.    |
| Density { 8.5—11 per cent ..... | 2.95                             |
| { 11—14 per cent .....          | 3.00                             |

Certain of the Lynite casting alloys manufactured by The Aluminum Castings Company are almost identical with the above Nos. 1 and 2. The composition and physical

properties of the Lynite alloys as guaranteed by the company are as follows<sup>2</sup>:

Lynite No. 146—for general castings, such as propellers, crank cases, etc.

|                      |                        |
|----------------------|------------------------|
| Copper .....         | 7.0—8.5 per cent.      |
| Other elements ..... | Not over 1.7 per cent. |
| Aluminium .....      | Balance.               |
| Density .....        | Not over 2.89.         |

Sand cast

|                          |                               |
|--------------------------|-------------------------------|
| Tensile strength .....   | 24,000—28,000 lb. per sq. in. |
| Elongation in 2 in. .... | 1.4 to 4.0 per cent.          |

Die cast

|                          |                              |
|--------------------------|------------------------------|
| Tensile strength .....   | About 28,000 lb. per sq. in. |
| Elongation in 2 in. .... |                              |

Lynite No. 122—for casting for use at higher temperatures: pistons, etc.

|                      |                         |
|----------------------|-------------------------|
| Copper .....         | 9.25 to 10.75 per cent. |
| Other elements ..... | Not over 2.0 per cent.  |
| Aluminium .....      | Balance.                |
| Density .....        | Not over 2.95.          |

Die cast

|                        |                              |
|------------------------|------------------------------|
| Tensile strength ..... | About 28,000 lb. per sq. in. |
|------------------------|------------------------------|

Lynite No. 109—for pressure castings.

|                      |                        |
|----------------------|------------------------|
| Copper .....         | 11.5 to 13.5 per cent. |
| Other elements ..... | Not over 1.7 per cent. |
| Aluminium .....      | Balance.               |
| Density .....        | Not over 2.97.         |

Sand cast

|                        |                        |
|------------------------|------------------------|
| Tensile strength ..... | 19,000 lb. per sq. in. |
| Elongation .....       |                        |

(3) "No. 31" (zinc 15 per cent, copper 3 per cent, aluminium 82 per cent).

Melting range: 625 to 440 deg. C.

Shrinkage: 0.156 in. per foot.

This alloy has hitherto been used more extensively abroad, particularly in Great Britain than here in this country. Its higher tensile strength as compared with No. 12 has not in this country outweighed the doubt in the minds of many of its performance and its freedom from deterioration upon aging. This illusion has now, it is believed, been largely dispelled and there seems no reason why the alloy should not become more popular.

This alloy can usually be depended on to give the following properties:

|                          |                               |
|--------------------------|-------------------------------|
| Tensile strength .....   | 22,000—25,000 lb. per sq. in. |
| Elongation in 2 in. .... | 0.5 to 3.0 per cent.          |
| Specific gravity .....   | 3.0                           |

When poured properly and at a low temperature a tensile strength of 30,000 lb. per sq.in. may be obtained with this alloy.

This alloy has a low resistance to alternating stresses, but is tougher in impact than the copper alloys (Nos. 1 and 2)<sup>3</sup>.

(4) Magnalium, 50 per cent alloy.

Melting range: 625 to 450 deg. C.

Shrinkage: 0.187 in. per foot.

This alloy is one of the earliest commercial alloys. The term originally connoting an alloy of aluminium containing from 5 to 30 per cent of magnesium, now covers a variety of commercial alloys containing magnesium and also small quantities of copper and nickel.

A "magnalium" used at one time by the Westinghouse Electric & Manufacturing Company (395) contains 5 per cent of magnesium. This alloy may be depended on to give the following tensile properties<sup>4</sup>:

|                          |                        |
|--------------------------|------------------------|
| Tensile strength .....   | 20,000 lb. per sq. in. |
| Elongation in 2 in. .... | 0.5—2.0 per cent.      |
| Specific gravity .....   | 2.63                   |

<sup>1</sup>Communication from The Aluminum Casting Co. through Prof. Z. Jeffries.

<sup>2</sup>Communication from Prof. Jeffries of The Aluminum Castings Co.

<sup>3</sup>Communication from M. J. I. Jones of the Westinghouse Co.

<sup>4</sup>Private communication from The Aluminum Castings Company, through Prof. Z. Jeffries.

With care a tensile strength of 25,000 lb. per sq.in. and an elongation of 5 per cent may be obtained.

(5) Alloy containing 35 per cent zinc.

Melting range: 585 to 440 deg. C.

Shrinkage: 0.156 in. per foot.

This alloy is much used for general castings in which strength is not a principal consideration. It casts well, but has little or no ductility. Its tensile strength is usually about 35,000 lb. per sq.in. as cast. Its specific gravity is 3.32.

(6) Alloy containing 1 to 2 per cent of copper and 1 per cent of manganese.

Melting range: 649 to 529 deg. C.

Shrinkage: 0.187 in. per foot.

This alloy is described by McKinney (453) and is suitable both for casting and for forging. Cupromanganese may be used in preparing it, and it is not apparently a difficult alloy to handle in the foundry. This alloy will usually have the following tensile properties or better:

Tensile strength .....18,000 lb. per sq. in.

Elongation in 2 in. .... 8 per cent.

Specific gravity .....about 2.80.

With care this alloy may be cast to have a tensile strength of 21,000 lb. per sq.in. with an elongation in 2 in. of 16 per cent. This alloy is used almost entirely by the Naval Gun Factory, Washington, D. C.

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#### ROLLING AND FORGING

Alloys for rolling or forging generally contain smaller percentages of the "hardener" metal than those for casting. Except when zinc is used, the total content of added metal to such alloys rarely exceeds 6 per cent and is usually less. The rolling or forging of these alloys is usually carried out in a manner quite similar to the practice followed for aluminium, although the temperatures used for hot breaking down are often somewhat lower owing to the lower melting point of the alloy, and it is usually annealed during cold rolling.

(1) Aluminium-manganese alloy.

An alloy (No. 3-S) containing manganese is rolled by the Aluminum Co. of America particularly into sheet, for use wherever a stiffer material than aluminium is desired. This alloy is superior to most other alloys of aluminium in its resistance to corrosion. The tensile properties of this alloy in sheet form average:

|                                          | Hard   | Soft   |
|------------------------------------------|--------|--------|
| Tensile strength in lb. per sq. in. .... | 30,000 | 15,000 |
| Elongation in 2 in. per cent. ....       | 2      | 25     |

(2) Alloy containing 1 to 2 per cent copper and 1 per cent manganese.

This alloy, used at the Naval Gun Factory (453), for small forgings may be readily forged at a temperature of about 625 deg. C. If finished at a temperature of about 250 deg. C. the forging is much harder. Forgings of this alloy give the following tensile properties:

|                                          | Finished cold | Finished hot |
|------------------------------------------|---------------|--------------|
| Tensile strength in lb. per sq. in. .... | 27,800        | 21,100       |
| Yield point in lb. per sq. in. ....      | 27,800 (?)    | 12,200       |
| Elongation in 2 in. per cent. ....       | 12            | 27           |
| Reduction of area, per cent. ....        | 47            | 49           |

The alloy is said to be quite satisfactorily resistant to corrosion in sea air.

(3) A forging alloy used by the Aluminum Castings Company has the following chemical composition:

Copper, 2.75 to 3.25 per cent; aluminium, the balance.

It will yield the following tensile properties:

Tensile strength .....24,000 lb. per sq. in.

Yield point .....16,000 to 17,000 lb. per sq. in.

Elongation in 2 in. ....not under 3.5 per cent.

(4) A machining rod alloy (No. 15-S) containing zinc and copper is produced by the Aluminum Co. of America. The average properties are:

Tensile strength .....42,000 lb. per sq. in.

Elongation in 2 in. .... 10 per cent.

(5) The Aluminum Co. of America recommends an alloy of from 10 to 15 per cent zinc for general forgings. This is said to flow well in the dies, and has satisfactory physical properties.

Iron, Carbon and Phosphorus.—DR. J. E. STEAD added another paper to his contributions on the behavior of phosphorus in iron and steel at the annual meeting of the Iron and Steel Institute held in London, May, 1918, in which he recounted a series of experiments showing qualitatively that the temperature where the phosphide of iron ( $\text{Fe}_3\text{P}$ ) passed into solid solution in ferrite varied with the amount present, thus conforming to the expected behavior of a binary system such as salt-water. In 1890 he noted that slow cooling from 1200 deg. C. of a 12-point steel containing 2 per cent phosphorus gave free phosphide along ferrite cleavages. Experimenting now with a decarburized blast furnace "bear" containing free phosphide envelopes and inclusions in ferrite crystals containing possibly 0.5 per cent P in solid solution he found that the free phosphide entered the solution at some temperature between 800 and 850 deg. C., and was nearly complete after 15 minutes at 960 deg. Diffusion is very slow, and on reheating at lower temperatures the phosphide re-crystallizes around the traces of the original crystals. Free crystals of iron-nickel phosphide (rhabdite) contained in a meteorite commenced to dissolve after 12 hours at 600 deg. C. Alloys containing 2 per cent phosphorus made by the thermit process showed solid solutions after 6 hours at 1000 deg., but developed new crystals freely after 6 hours at 800 deg. C. A rolled bar which had previously been phosphized at a white heat was bedded in mill scale, and one end heated to 961 deg. C. for 60 hours. Phosphide crystals appeared in that portion which had been held at a temperature of 660 up to 900 deg., increasing in size with the temperature. In absolute amount they were maximum at 800 to 850 deg. C., while at 961 deg. a homogeneous solid solution existed. No eutectic films were shown, and no phosphide crystals were present in decarburized eutectoid zones, since phosphide and carbide are mutually repellant. Pearlitic areas in phosphoretic steel castings and the ferrite immediately adjacent are nearly phosphorous-free, while the body of the ferrite crystals contain the phosphide in solid solution. In the cementation of phosphoretic steel, the migrating carbon drives the phosphorus before it, eventually making localized spots of concentrated iron-iron phosphide solid solution. The specific amount of carbon absorbed therefore varies with the phosphorous content. At 1200 to 1300 deg. C. the concentrated  $\text{Fe-Fe}_3\text{P}$  solution melts at the center of the ferrite crystal in a globule, and on being further heated, eventually liquates as a ternary  $\text{Fe-P-C}$  eutectic.







## Personal

MR. G. A. ARMSTRONG has severed his connections with E. J. Loomis & Co., Philadelphia, Pa., to accept a position as chemical engineer in charge of intermediates with the Central Dyestuff and Chemical Co., Newark, N. J.

MR. W. J. ARMSTRONG, manager of the crushing and pulverizing sales department of the Jeffrey Manufacturing Company, Columbus, Ohio has recently received an appointment as captain in the United States Army and assigned to the Ordnance Department in Washington, D. C.

MR. ZENO D. BARNES is now connected with the general operating department of The Aluminum Castings Company, with headquarters in Cleveland. For the past three years Mr. Barnes was non-ferrous metallurgist for the Westinghouse Air Brake Co.

PROFESSOR GEORGE BORROWMAN has taken up research work for the Niagara Alkali Company under the direction of Dr. John E. Teeple, 50 East 41st Street, New York. He was formerly at the University of Nebraska.

MR. CYRIL B. CLARK of the Research Department of the General Chemical Company, New York, has been detailed on some special work for this company's Bay Point Works near San Francisco. Mr. Clark expects to return to New York in four months when the work is to be completed.

MR. JOHN A. COYE has accepted the position of assistant chemist with the General Chemical Company's Laurel Hill works.

MR. CONRAD DRESSLER has been awarded the John Scott medal by the Franklin Institute of Philadelphia in recognition of his contribution to the advancement of the science of firing (furnaces for annealing, etc.).

CAPTAIN J. J. GAILLARD has assumed the position of district engineer in charge of the Atlanta office, Portland Cement Association, succeeding Mr. W. Jess Brown who resigned to accept a commission as captain in the Ordnance Department, U. S. Army. Captain Gaillard joined the forces of the Portland Cement Association January 1, 1918, and since that time has been doing general promotion and inspection work in the district covered by the Atlanta office of the association.

MR. CHARLES HENROTIN of Haileybury, Ont., is operating a fluorspar property near Madoc, Ont., and is shipping this product to the United States.

MR. C. A. NASH has accepted the position of research chemist with the Cutler-Hammer Manufacturing Company, of Milwaukee. Mr. Nash was formerly associate in chemistry at the University of Chicago.

MR. L. J. PLETCHER has withdrawn from teaching to enter the service of the Texas Refinery, Port Arthur, Texas as research chemist.

DR. J. H. RANSOM has been elected professor of chemistry and director of the chemical laboratories in Vanderbilt University, Nashville, Tenn. Dr. Ransom has been at Purdue University for the last eighteen years.

MR. CHARLES F. ROTH, one of the managers of the National Exposition of Chemical Industries and Secretary of the New York Section of the American Chemical Society is in the Personnel Section of the Chemical Warfare Service where he has charge of the census of chemists which is being taken by the War Department.

MR. L. DUANE SIMPKINS has accepted the position as chief metallurgical chemist and metallographer for the Peters Cartridge Co., Kings Mills, Ohio.

to get his supply, but his status in war production, that directs the allocation of the metals.

**Aluminium:**—The Government prices on ingots 98 to 99 per cent Al are \$660 a ton f.o.b. plant in 50-ton lots; \$662 down to 15-ton lots; and \$666 down to 1-ton lots, which prices will continue the remainder of the year. Prices per pound for small lots vary from 40 to 45c; sheet aluminium, 18ga. and heavier, 42c; powdered aluminium, 100 mesh, 70c.

**Antimony:**—The recent rise in antimony was but temporary, the price now being 14 to 14½c. for duty paid spot delivery.

**Chrome:**—Western production is now in slight excess of demand. The nominal quotation for 40 per cent ore is \$1.40 per unit, while 50 per cent ore is bringing \$1.70.

**Copper:**—The price of \$520 per ton for car load lots and 27.3c. per pound for small quantities is permanently fixed.

|                                     |        |          |
|-------------------------------------|--------|----------|
| Copper sheets, hot rolled..... lb.  | \$0.36 | —\$0.37½ |
| Copper sheets, cold rolled..... lb. | .37    | — .38½   |
| Copper bottoms..... lb.             | .44    | — .45½   |
| Copper rods..... lb.                | .36    | — .37    |
| Copper wire..... lb.                | .29½   | — .30    |
| High brass wire..... lb.            | .28½   | — .29½   |
| High brass sheets..... lb.          | .28    | — .29    |
| High brass rods..... lb.            | .26½   | — .28½   |
| Low brass wire..... lb.             | .32½   | — .34½   |
| Low brass sheets..... lb.           | .32½   | — .34½   |
| Low brass rods..... lb.             | .33½   | — .35½   |
| Brazed brass tubing..... lb.        | .37    | — .39    |
| Brazed bronze tubing..... lb.       | .42½   | — .44½   |
| Seamless copper tubing..... lb.     | .41    | — .43    |
| Seamless bronze tubing..... lb.     | .45    | — .46    |
| Seamless brass tubing..... lb.      | .37½   | — .39½   |
| Bronze (gold) powder..... lb.       | 1.00   | — 1.75   |

**Lead:**—The lead market is limited by selling restrictions. Producers must sell at a uniform and pre-arranged price. In car load lots at East St. Louis, the price is \$155 per ton. In New York, all speculative and traders' lead has disappeared. The Lead Committee apportions lead at 8.05c. to legitimate consumers.

**Manganese:**—The scale prices on page 629 of CHEMICAL & METALLURGICAL ENGINEERING, June 15, prevail; the highest price per unit being \$1.35.

**Zinc:**—Spelter continues to advance. East St. Louis is selling at \$183 to \$185 per ton in car lots; New York quotations are from 9.4 to 9.5c. per pound; sheet zinc 15c. and zinc dust (300 mesh) 16c. per pound in 1600-lb. casts.

**Silver:**—The Government price of \$1.01½ is hoped to promote production.

**Tin:**—The market is awaiting further development on the inter-Allied conference on tin. The War Industries Board will soon announce regulation prices and control the distribution of our \$0,000-ton allocation. Tin is priced at 80c. per pound nominally.

**Tungsten:**—The western producers of scheelite are reluctant in offering at \$25.50 per unit. High grade wolframite is bringing \$25. Off-grade ores vary from \$20 to \$24.

### OTHER METALS

|                     |        |         |
|---------------------|--------|---------|
| Blismuth..... lb.   | \$3.50 | —\$3.65 |
| Cadmium..... lb.    | 1.50   | — 1.60  |
| Cobalt..... lb.     | 2.50   | — 3.50  |
| Magnesium..... lb.  | 1.75   | — 2.00  |
| Mercury..... 75 lb. | 125.00 | —       |
| Mercury..... lb.    | 1.75   | —       |
| Nickel..... lb.     | 1.40   | — .48   |
| Iridium..... oz.    | 175.00 | —       |
| Palladium..... oz.  | 135.00 | —       |
| Platinum..... oz.   | 105.00 | —       |

### The Iron and Steel Market

On September 23 the War Industries Board began holding a series of meetings with representatives of different branches of the iron and steel trade to consider two things: (1) Possibilities of increasing production of steel; (2) possibilities of conserving steel by reducing the amount converted into various finished products. The board had previously called upon all war activities to pare their estimates of steel required as much as possible. This work is dictated by the fact that the estimated requirements for the half year still total 23,000,000 net tons while the production can hardly materially exceed 19,000,000 tons. One finished steel product is not considered, except in a general way, by the War Industries Board, that being tin plate, which is under the jurisdiction of the Food Administration. Early last May the production and shipment of tin plate

## Current Market Reports

### The Non-Ferrous Metal Market

*Tuesday, Sept. 25.*—The metal markets are quiet, distribution being under Government control; varying monetary offerings can exert no influence on the market. It is no longer a question of what a certain manufacturer will give

was required to be confined to the filling of Government orders and the requirements of the perishable foods. Early in September, with the end of the canning season near at hand, an order was issued restricting by 30 per cent the manufacture of tin plate during the fourth quarter. While it had been expected that at the end of the canning season tin plate would be allowed to go to the non-perishable foods, and perhaps also to other lines of consumption, the Food Administration made no order, but undertook to meet, in order, representatives of the packers of the various non-perishable foods, for the purpose of limiting their consumption of tin plate. At this writing the tin plate trade is in expectation of receiving orders to cut its production by still more than the 30 per cent originally prescribed.

The outstanding feature of the present situation as to steel supplies is that all the news relates to efforts to conserve steel by reducing the amount consumed by various finishing operations. Excepting the one item of rails, there is no important activity which is specifically designated as requiring an increased supply of steel. From one viewpoint, the strenuous efforts being made to conserve steel would suggest that there is a great shortage, but from another viewpoint there is the opposite suggestion, that by conservation along various lines a considerable tonnage of steel may be released while there is no well defined additional use to which the steel would be put, excepting in the one case of rails. As to rails, the Railroad Administration has been calling for 60,000 tons a week and has been receiving 40,000 tons, which, in 85-pound rails, is enough to lay 300 miles of track per week, and there is a question whether labor can be provided for any greater activity than this. The American Expeditionary Force has been calling for large tonnages of rails, and it is desired to increase the rate of shipment, though by what weekly tonnage is not known. If there is a deficiency in rails it certainly does not amount to any large fraction of the much talked-of 4,000,000 ton deficiency in steel in general.

Thus the aspect of the great question, whether or not there is enough steel, continues to change. Late in 1917 many steel producers expected steel to become plentiful within a few months, through the peace consumption decreasing. The sharp curtailment in production during the winter caused a postponement of the time at which steel was expected to become plentiful, a not uncommon view being that steel might be plentiful in April. Just at the beginning of that month the Director of Steel Supply began a campaign to convince the steel makers that more war steel was required and during the next three months the distribution of the entire output of steel was taken over by the War Industries Board. Eventually the steel industry was convinced that direct war needs and essential commercial requirements would absorb the entire output, while the shortage of several million tons the War Industries Board insisted would occur in the second half of the year was considered quite seriously. After the lapse of three months of the half year, however, with no evidence of any large deficiency accumulated, some doubt is beginning to be felt.

#### OPERATING CONDITIONS

Shortage of labor is felt more or less throughout the iron and steel industry, but no such shortage as to interfere seriously with production. The bottle neck, so far as steel output is concerned, is the supply of pig iron. More steel could be made, with the same supply of labor, if there were more pig iron. The present supply of pig iron, however, would be adequate if there were at the same time a normal supply of scrap, but war time conditions cause the outcome of scrap to be much less than normal.

The supply of pig iron, again, is much below what would be expected of the blast furnaces in operation if they were given normal operating conditions. Since April 1 the rate of pig iron production has been between 40,000,000 and 41,000,000 tons a year. Various comparisons, of the output in 1916, with allowance for new furnaces completed since the beginning of that year, and of the number of furnaces lately in blast, indicate that under 1916 conditions the output of pig iron should be at the rate of at least 43,000,000

tons a year. The cause of the discrepancy has been earnestly sought and the common disposition among furnacemen is to attribute the discrepancy chiefly to the quality of coke available. This led the Fuel Administration several weeks ago to undertake a system of coke inspection, while at the same time, by speeches and otherwise, the miners are urged to mine cleaner coal and the operators to pay more attention to coke quality in general. One coke operator has been required to refund \$80,000 to customers, and another \$75,000, on account of inferior coke furnished in recent months, and in future coke not up to standard is to be penalized in price \$1 a ton. Analysis of the Geological Survey's weekly reports of coke production indicates that the quantity of coke being produced is sufficient. The rate is 61,000,000 net tons a year, about 47 per cent by-product and 53 per cent beach, with the by-product increasing nearly every week.

Pig iron production increased somewhat during September and still better output is expected in October, traditionally the best month of the year for furnace operations. Late in September the Brier Hill Steel Company, Youngstown, O., completed a new furnace, and if the report is correct that the furnace cost \$3,000,000 a new record has certainly been set in blast furnace construction. Unless after the war there is to be no reversion at all to pre-war conditions, a very heavy amortization charge is imperative against such new construction.

#### FOURTH QUARTER PRICES

In many branches of the iron and steel trade claims were made that in the adjustment of prices for the fourth quarter various advances should be made. These claims were formulated in rather elaborate manner, with many meetings of the interests involved. The outcome was an advance of 25 cents a ton in Lake Superior iron ore, intended to cover wage advances, as the 45-cent advance effective July 1 was absorbed almost entirely by the freight rate advance, and an intricate advance in pig-iron prices. Unfinished and finished steel prices were not altered.

The price of each grade of pig iron had been uniformly f.o.b. furnace. All basis prices were advanced \$1 a ton, except that for Bessemer iron. Tennessee and Virginia furnaces were removed from the furnace basis and placed on a Birmingham basis. Furnaces north of the Potomac River and east of the Allegheny Mountains were placed on a Pittsburgh basis. Thus in the case of foundry iron 1.75 to 2.25 per cent silicon, the Tennessee furnace formerly sold at a delivered price of \$33 plus freight from furnace to delivery point, but will now sell at \$34 plus freight from Birmingham to delivery point, the realized price being increased by \$1 plus the freight advantage. As further illustrative of the new price schedule, the New England consumer formerly patronized the furnace making the lowest delivered price, Buffalo, eastern Pennsylvania, Virginia and Alabama being more or less in competition. Now the prices made by the four districts will show wide variations, Buffalo selling at \$34 plus freight from Buffalo, eastern Pennsylvania at \$34 plus freight from Pittsburgh and Virginia and Alabama at \$34 plus freight from Birmingham. The consumer will choose when he can but will have to take iron from the furnace that can supply it. The arrangement is logical only in that it takes account that the costs have increased more in some districts than in others.

#### The Chemical Market

**COAL TAR PRODUCTS:**—Active trading has been more pronounced for the past two weeks in the majority of intermediates. However, activity in some of the items was curtailed by the scant supply of certain crudes and other unfavorable conditions that are prevailing. Prices on the whole are maintained at firm levels while some of the products have a strong upward tendency. Of these are benzol and phenol, which have attained a firmer position.

**Benzol:**—The actual trading position of this item has been rather erratic during the past two weeks, the latter period of which a firm situation developed with a fractional increase in price in tank car material and also that in drums. Stocks, however, are in liberal supply, but the demand is becoming more pronounced.



**Phenol:**—The market for this item has also developed a firmer tone. Its position, however, has been seemingly brought about by extensive purchasing for export purposes, while local requirements are reasonably active, in so far as the steady routine of business, which is generally passing. The firmness therefore having caused an increase in prices.

**Paranitraniline:**—The interest is persistent and the scarcity of stocks, which have been prevailing for some time, is at present offering no encouragement. The scattered spot lots which appear on the market are held at a variation of prices that trading is only as pressing requirements demand.

**Pora Amidophenol:**—The material is neither in pronounced demand nor supply. Prices continue at the same firm levels.

**Paranitrotoluol:**—Factors in this line are all sold up and the occasional lots which appear on the market are absorbed readily. Prices, however, remain at firm levels.

**Diethylaniline:**—Most producers are sold ahead for a fair period and supplies that are available are held mainly in second hands. The demand is steady and prices are quotably unchanged.

**Benzoate of Soda:**—A strengthening situation has become in evidence during the recent period with an advance in prices. It is the prevailing impression a higher market level will be seen, in view of the strong buying interest, more noticeable, however, for the acid material.

**Aniline Oil:**—The volume of business passing is apparently having no material effect on the quantity of stocks, though no unusual surplus is reported on hand. Prices are firm though, in some directions, fractionally easier.

**H-Acid:**—Spot lots are difficult to locate and producers are generally out of the market. Therefore prices are quotably nominal.

**Sulphuric Acid:**—Production continues to be confined to a few dealers. Prices are firm but the market is rather quiet, and supplies are in accordance with the consuming requirements.

**Toluol:**—The position of this material is no easier. It may be stated that only small quantities of the product are released by the Government, which has the entire situation in hand.

**Phthalic Anhydride:**—A strong demand with only limited stocks is the position of this item. Prices are without quotable change in view of the stringent situation.

**Metatoluylenediamine:**—The production of this material is not liberal, due to the toluol situation and, while the demand is only general, stocks are scarce. Quotations heard are still at firm levels.

**HEAVY CHEMICALS:**—The items that fall under this classification have in a number of instances commanded considerable interest in the past two weeks. Though many of the products which are in steady demand through routine channels have otherwise not been noticeably active and subject to no material change. Prices for the latter mentioned have undergone no particular fluctuations, though in some directions slightly lower levels were in evidence. Caustic soda, however, and its allied product, soda ash, were the prominent features of the market. Each of the items reaching levels, during the close, that were considered unusually high with no easement in sight and considerable speculation as to the futures. The supply of all acids continues scarce.

**Soda Ash:**—The volume of business in New York during the past two weeks has been exceedingly active. It may be safely stated that each day developed a more strengthening position, with prices increasing accordingly. The firmness coincident with the diminishing stocks made it appear as though the market was destined to unheard-of levels. Single bags were sold at from \$2.55 to \$2.60 warehouse, barrels from local store were generally held at \$3.15 minimum, and up to \$3.25. Double bags rolling to the coast were quoted at \$3.15 to \$3.20 and a car of dense ash rolling to the coast was held at \$5.15 coast.

**Sodium Cyanide:**—The item is more or less neglected in the open market and trading is mainly through routine channels. In the resale market spot lots were offered at from 31c. to 34c.

**Caustic Soda:**—The item during most of the past week has been exceedingly strong and to such an extent that stocks are diminishing in consequence of the pressing demand. On the spot prices ranged from \$4.30 to \$4.80, though the sale of the latter was generally regarded as high with the opinion that \$4.30 to \$4.35 represented the true market price for spot material. However, at these quotations offerings were scarce and material was held at such figures that large consumers displayed hesitancy in closing. Figures for over the balance of the year were \$4.35 f.o.b. works and for immediate shipment offerings were made at from \$4.35 to \$4.40 works, according to the seller.

**Pernmanganose of Potash:**—Production of this material under ordinary conditions has apparently been sufficient to take care of the consumption demand. But circumstances have created a sudden change during the latter end of the past week when a strengthening situation developed. Therefore in the open market sales have been reported at higher levels than were noted for some time and at the closing the U. S. P. material was generally held at from \$1.90 to \$2.00 with active trading at these figures, though in some directions the prices could be shaded. The technical product in sympathy with the U. S. P. has attained a firmer position and prices range from \$1.60 to \$1.75 according to quality and some of the higher grades are held at \$1.80.

**Bichromate of Soda:**—No unusual interest is evidenced for this material and it is difficult to determine its position in the market. Stocks are in liberal quantities and the entire situation is seemingly in favor of the buyer. Some low quotations are heard and sales are passing from 23c. to 24c.

**Bleaching Powder:**—Prices for this commodity have advanced in leaps and bounds during the interval and authorities in this line predict a 6c. market and perhaps higher prices in the near future. There seems to be a question at present writing, as to what the actual market level is. October-November-December were available at \$4.50 subject to government control, or requisition and some traders would not shade 4½c. for November or December. A report from the American Consulate-General, London, September 16, states:—

The Ministry of Munitions notifies that from September 16 no person shall produce or manufacture chlorine or chlorine compounds in quantities exceeding one-tenth per month under license, nor shall more than 10 be employed by manufacturer for purposes of other manufacturers, trades, and business except under license. From September 16 no person shall sell or offer for sale or purchase any liquid chlorine or bleaching powder exceeding following maximum prices: Liquid chlorine 6d, per pound, bleaching powder £15 per ton. However, maximum prices do not apply to goods for export from United Kingdom or sales of less than 56 pound weight.

**Carbon Bisulphide:**—In the situation of this material there is little change noted and trading is reasonably active. Prices remain firm in most instances at from 8 to 9c. f.o.b. works and 7½c. f.o.b. works, contract basis.

**Carbonate of Magnesia:**—The market has been barely steady with sellers offering various quotations and on the whole the item has been neglected by the majority of users. The technical is held at from 15 to 16c. ex store in bags of 100 lb. for less than carload lots and in larger quantities 14 to 15c. f.o.b. mills is the general asking price.

**Magnesia, Calcined:**—The high grade technical which is mainly in demand by the rubber making trade is an active item and is offered at 65 to 75c. medium grades, at 40 to 50c. and the heavy at from 9½ to 12c. Interest in the item is nothing of consequence, other than the regular routine of business.

**Bicarbonate of Soda:**—The present production of this material is reported to be insufficient to take care of all the business now placed. However, frequent lots appear on the market and two cars of this material for October-November delivery were quoted at \$3.10. The price is considered low as efforts to cover at \$3.25 were reported as unsuccessful. The market for prompt shipment is quoted by factors to be \$3.40 to \$3.50.



## General Chemicals

| WHOLESALE PRICES IN NEW YORK MARKET, SEPT. 24, 1918 |      |               |         |
|-----------------------------------------------------|------|---------------|---------|
| Acetic anhydride                                    | lb.  | 1.60          | 1.85    |
| Acetone                                             | lb.  | 25            | 25      |
| Acetic, 28 per cent.                                | cwt. | 5             | 6 11    |
| Acetic, 36 per cent.                                | cwt. | 10 76         | 10 87   |
| Acetic, glacial, 99 1/2 per cent. carboxy.          | cwt. | 19 00         | 19 20   |
| Boric, crystals                                     | lb.  | 131           | 15      |
| Calcic, crystals                                    | lb.  | 82            | nominal |
| Hydrochloric, C. P.                                 | lb.  | nominal       | nominal |
| Hydrofluoric, 30 per cent in barrels                | lb.  | 08            | 08 1/2  |
| Lactic, 44 per cent.                                | lb.  | 15            | 16      |
| Lactic, 22 per cent.                                | lb.  | 5             | 44      |
| Molybdic, P.                                        | lb.  | 6.90          | 7.40    |
| Nitric, 36 deg.                                     | lb.  | nominal       | nominal |
| Nitric, 42 deg.                                     | lb.  | 08 1/2        | 10      |
| Oxalic, crystals                                    | lb.  | 4             | 44      |
| Phosphoric, 47-50 per cent paste.                   | lb.  | 07 1/2        | 10      |
| Phosphoric, ref. 50 per cent.                       | lb.  | 35            | 40      |
| Picric                                              | lb.  | 75            | 85      |
| Pyrogallic, resublimed                              | lb.  | 3             | 3.50    |
| Sulphuric, 60 deg.                                  | ton  | 18 00         | 20      |
| Sulphuric, 66 deg.                                  | ton  | 28 00         | 30      |
| Sulphuric, oleum (Fuming), tank cars                | ton  | 60 00         | 65 00   |
| Tannic, U. S. P., bulk                              | lb.  | 1.40          | 1.50    |
| Tartaric, crystals                                  | lb.  | 86            | 95      |
| Turmeric, per lb. of W.                             | gal. | 4             | 1.75    |
| Alcohol, sugar cane, 188 proof                      | gal. | 91            | 92      |
| Alcohol, wood, 95 per cent.                         | gal. | 91 1/2        | 92      |
| Alcohol, denatured, 180 proof.                      | gal. | 68            | 69      |
| Alum, ammoniac lump                                 | lb.  | 06            | 06      |
| Alum, chrome ammonium                               | lb.  | 21            | 22      |
| Alum, chrome potassium                              | lb.  | 21            | 22      |
| Alum, chrome sodium                                 | lb.  | 12 1/2        | 13      |
| Alum, potash lump                                   | lb.  | 04 1/2        | 10      |
| Aluminum sulphate, technical                        | lb.  | 04            | 04 1/2  |
| Aluminum sulphate, iron free                        | lb.  | 03 1/2        | 04      |
| Ammonia aqua, 26 deg. carboxy                       | lb.  | 08 1/2        | 09      |
| Ammonia, anhydrous                                  | lb.  | nominal       | nominal |
| Ammonium carbonate                                  | lb.  | 12            | 13      |
| Ammonium nitrate                                    | lb.  | (Fixed Price) | 13      |
| Ammonium sulphate domestic                          | lb.  | 07 1/2        | 08      |
| Amper carbonate                                     | gal. | 5 10          | 5 35    |
| Arsenic, white                                      | lb.  | 09 1/2        | 13      |
| Arsenic, red                                        | lb.  | 65            | 70      |
| Barium carbonate, 99 per cent.                      | ton  | 80 00         | 90 00   |
| Barium chloride, 97-98 per cent.                    | ton  | 65 00         | 67 00   |
| Barium chloride                                     | ton  | 70 00         | 80 00   |
| Barium sulphate (Blanc Fixe, Dry)                   | lb.  | 04 1/2        | 05      |
| Barium nitrate                                      | lb.  | 12            | 14      |
| Benzene peroxide, basis 70 per cent                 | lb.  | 65 00         | 70 00   |
| Bleaching powder, 35 per cent chlorine              | lb.  | 05            | 05 1/2  |
| Borax, crystals, sacks                              | lb.  | 08 1/2        | 08 1/2  |
| Bromine, crude                                      | ton  | 65 00         | 70 00   |
| Bromine, technical                                  | lb.  | 08 1/2        | 10      |
| Calcium, acetate, crude                             | lb.  | 04            | 05      |
| Calcium, carbide                                    | lb.  | 22 00         | 24 00   |
| Calcium chloride, 70-75 per cent, fused, lump.      | ton  | 12 00         | 13 00   |
| Calcium peroxide                                    | lb.  | 22            | 23      |
| Calcium phenolate                                   | lb.  | 22            | 23      |
| Calcium sulphate-98-99 per cent.                    | lb.  | 09            | 09 1/2  |
| Calcium bisulphide                                  | lb.  | 08            | 07      |
| Carbon tetrachloride, drums                         | lb.  | 06            | 07      |
| Carbonyl chloride (phosgene)                        | lb.  | 1 00          | 1 50    |
| Ceasur potash, 88-92 per cent.                      | lb.  | 65            | 77 1/2  |
| Ceasur soda, 40 per cent.                           | lb.  | 4 25          | 4 40    |
| Chlorine, liquid (Government Purchase)              | 100  | (Fixed Price) | 07 1/2  |
| Cobalt oxide                                        | lb.  | 1 60          | 1 65    |
| Copper                                              | lb.  | 02 1/2        | 02 1/2  |
| Copper carbonate                                    | lb.  | 3 75          | 3 75    |
| Copper cyanide                                      | lb.  | 75            | 78      |
| Copper sulphate, 99 per cent, large crystals        | lb.  | 09 1/2        | 09 1/2  |
| Cream of tartar, crystals                           | lb.  | 76            | 80      |
| Croton salt, basic U. S. P.                         | 100  | 3 10          | 3 30    |
| Formaldehyde, 40 per cent.                          | lb.  | 16 1/2        | 17      |
| Glauber's salt                                      | lb.  | 02 1/2        | 03      |
| Glycerine, bulk, C. P.                              | lb.  | 63            | 65      |
| Iodine, resublimed                                  | lb.  | 4 25          | 4 30    |
| Iron oxide                                          | lb.  | 13            | 15      |
| Lead acetate, white crystals                        | lb.  | 17            | 17 1/2  |
| Lead arsenate (Paste)                               | lb.  | 17            | 18      |
| Lead nitrate                                        | lb.  | nominal       | nominal |
| Litharge, American                                  | lb.  | 12            | 14      |
| Lithium carbonate                                   | lb.  | 1 50          | 2 05    |
| Magnesium carbonate, technical.                     | lb.  | 16            | 17      |
| Nickel salt, single                                 | lb.  | 14            | 15      |
| Nickel salt, double                                 | lb.  | 12            | 13      |
| Phosgene, (see Carbonyl chloride)                   | lb.  | 10            | 12      |
| Phosphoric, ref.                                    | lb.  | 1 10          | 1 20    |
| Phosphoric, yellow                                  | lb.  | 1 10          | 1 20    |
| Potassium bicarbonate                               | lb.  | 45            | 46      |
| Potassium bromide granular                          | lb.  | 1 25          | 2 26    |
| Potassium carbonate, calcined, 85-90 per cent.      | lb.  | 38            | 40      |
| Potassium chlorate, crystals                        | lb.  | 38            | 40      |
| Potassium cyanide, 98-99 per cent                   | lb.  | 60            | 70      |
| Potassium iodide                                    | lb.  | 35            | 38      |
| Potassium murate 80-85 p. c. basis of 80 p. c.      | ton  | 300 00        | 350 00  |
| Potassium nitrate                                   | lb.  | 27            | 31      |
| Potassium permanganate U. S. P.                     | lb.  | 1 65          | 1 80    |
| Potassium persulfate, red                           | lb.  | 2 50          | 2 50    |
| Potassium persulfate, yellow                        | lb.  | 2 50          | 1 10    |
| Potassium sulphate, 90-95 p. c. basis 90 p. c.      | ton  | nominal       | nominal |
| Rochelle salts                                      | lb.  | 47            | 48      |
| Salammoniac, gray gran                              | lb.  | 19            | 20      |
| Salammoniac, white gran                             | lb.  | 1 40          | 1 65    |
| Salt soda                                           | 100  | 22 50         | 25 00   |
| Salt cake                                           | ton  | 22 50         | 25 00   |
| Silver cyanide, based on market price of silver     | oz.  | 6 1/2         | 6 1/2   |
| Silver nitrate                                      | oz.  | 6 1/2         | 6 1/2   |
| Soda ash, 58 per cent, light, flat (bags)           | 100  | 2 60          | 3 80    |
| Soda ash, 58 per cent, dense, flat                  | 100  | 5 75          | 6 80    |
| Sodium acetate                                      | lb.  | nominal       | nominal |
| Sodium bicarbonate, domestic                        | lb.  | 03            | 04      |
| Sodium bicarbonate, English                         | lb.  | 23 1/2        | 24      |
| Sodium bisulphate                                   | lb.  | 12            | 14      |
| Sodium bisulphate, powd.                            | lb.  | 25            | 25 1/2  |
| Sodium chloride                                     | lb.  | 25            | 25      |
| Sodium cyanide                                      | lb.  | 30            | 35      |
| Sodium fluoride, commercial                         | lb.  | 17            | 18      |

|                                        |      |         |         |
|----------------------------------------|------|---------|---------|
| Sodium hypophosphite                   | lb.  | 2 80    | 3 00    |
| Sodium metasilicate, per lb. of Mo.    | lb.  | 2 50    | 2 50    |
| Sodium nitrate, 95 per cent.           | 100  | 4 12    | 5 00    |
| Sodium nitrite                         | lb.  | 27      | 30      |
| Sodium peroxide                        | lb.  | 35      | 45      |
| Sodium phosphate                       | lb.  | 34      | 44      |
| Sodium pyrosulphate, yellow            | lb.  | 39      | 40      |
| Sodium silicate, liquid (60 deg.)      | lb.  | 02 1/2  | 03 1/2  |
| Sodium sulphide, 10 per cent, crystals | lb.  | 06 1/2  | 07      |
| Sodium sulphide, 60 per cent, fused    | 100  | 10      | 10 1/2  |
| Sodium sulphate                        | lb.  | 03 1/2  | 04      |
| Sroutium nitrate                       | lb.  | 25      | 30      |
| Sulphur chloride, drums                | lb.  | 07 1/2  | 09      |
| Sulphur dioxide, liquid, in cylinders  | gal. | 39      | 40      |
| Sulphur, flowers, sublimed             | 100  | 4 35    | 4 50    |
| Sulphur, roll                          | 100  | 3 70    | 3 85    |
| Sulphur, crude                         | ton  | 65 00   | 70 00   |
| Tin bichloride, 50 deg.                | lb.  | 28      | 29      |
| Tin oxide                              | lb.  | nominal | nominal |
| Zinc carbonate                         | lb.  | 18      | 20      |
| Zinc chloride                          | lb.  | 15      | 15 1/2  |
| Zinc cyanide                           | lb.  | nominal | nominal |
| Zinc dust, 350 mesh                    | lb.  | 13 1/2  | 14      |
| Zinc oxide, American process XX        | lb.  | 12 1/2  | 14      |
| Zinc sulphate                          | lb.  | 04 1/2  | 06 1/2  |

## Coal Tar Products (Crude)

|                                        |      |               |       |
|----------------------------------------|------|---------------|-------|
| Benzol, pure, water white              | gal. | 23            | 28    |
| Benzol, 90 per cent                    | gal. | 25            | 25    |
| Toluol, in tank                        | gal. | (Fixed Price) | 1 50  |
| Toluol, for non-military use, in drums | gal. | (Fixed Price) | 1 45  |
| Xylo, pure, water white                | gal. | 45            | 55    |
| Solvent naphtha, water white           | gal. | 18            | 25    |
| Solvent naphtha, crude, heavy          | gal. | 12            | 15    |
| Cresote oil, 25 per cent               | gal. | 45            | 55    |
| Dipol, 20 per cent                     | gal. | 30            | 32    |
| Pitch, various grades                  | ton  | 8 00          | 20 00 |
| Carbolic acid, crude, 95-97 per cent.  | lb.  | 1 60          | 1 10  |
| Carbolic acid, crude, 50 per cent.     | lb.  | 60            | 65    |
| Carbolic acid, crude, 25 per cent.     | lb.  | 35            | 38    |
| Cresol, U. S. P.                       | lb.  | 19            | 20    |

## Intermediates, Etc.

|                                 |     |         |         |
|---------------------------------|-----|---------|---------|
| Alpha naphthol, crude           | lb. | 1 00    | 1 10    |
| Alpha naphthol, refined         | lb. | 1 50    | 1 60    |
| Alpha naphthylamine             | lb. | 55      | 60      |
| Aniline, drums extra            | lb. | 44      | 45      |
| Aniline salts                   | lb. | 44      | 45      |
| Anthracene, 80 per cent.        | lb. | nominal | nominal |
| Benzaldehyde (f. c.)            | lb. | 4 25    | 4 50    |
| Benzidine, base                 | lb. | 1 40    | 1 45    |
| Benzidine, sulphate             | lb. | 1 40    | 1 45    |
| Benzic acid U. S. P.            | lb. | 2 75    | 2 95    |
| Benzoate of Soda, U. S. P.      | lb. | 2 75    | 2 95    |
| Benzyl chloride                 | lb. | 2 45    | 2 50    |
| Beta naphthol benzene           | lb. | 10 00   | 12 00   |
| Beta naphthol, sublimed         | lb. | 75      | 85      |
| Beta naphthylamine, sublimed    | lb. | 2 65    | 2 75    |
| Dichlor benzol                  | lb. | 1 15    | 1 20    |
| Diethylaniline                  | lb. | 4 00    | 4 50    |
| Dinitro benzol                  | lb. | 36      | 38      |
| Dinitrochlorobenzol             | lb. | 40      | 45      |
| Dinitrotrichlorobenzol          | lb. | 55      | 60      |
| Dinitrotoluol                   | lb. | 65      | 75      |
| Dinitrophenol                   | lb. | 55      | 74      |
| Dimethyl aniline                | lb. | 74      | 80      |
| Diphenylamine                   | lb. | 1 00    | 1 10    |
| H-acid                          | lb. | 3 25    | 3 50    |
| Metaphenylenediamine            | lb. | 1 85    | 2 05    |
| Monochlorobenzol                | lb. | 1 15    | 1 20    |
| Naphthalene, flake              | lb. | 09      | 09 1/2  |
| Naphthalene, ball               | lb. | 11      | 12 1/2  |
| Naphthionic acid, crude         | lb. | 1 10    | 1 30    |
| Naphthylamine of sulphonic acid | lb. | 1 00    | 1 10    |
| Nitro naphthalene               | lb. | 45      | 50      |
| Nitro toluol                    | lb. | 55      | 60      |
| Ortho-amidophenol               | lb. | 15      | 15      |
| Ortho-dichlorobenzol            | lb. | 15      | 20      |
| Ortho-toluidine                 | lb. | 1 00    | 1 10    |
| Ortho-nitro-toluol              | lb. | 75      | 85      |
| Para-amidophenol, base          | lb. | 4 00    | 4 50    |
| Para-amido-phenol, H. Cb.       | lb. | 4 25    | 5 00    |
| Para-dichlorobenzol             | lb. | 15      | 20      |
| Paranitraniline                 | lb. | 1 80    | 1 95    |
| Para-nitro-toluol               | lb. | 1 80    | 1 60    |
| Paraphenylenediamine            | lb. | 4 00    | 4 50    |
| Para toluidine                  | lb. | 2 00    | 2 25    |
| Phthalic acid anhydride         | lb. | 4 00    | 4 50    |
| Phenol, U. S. P.                | lb. | 4 00    | 4 50    |
| Resorcin, technical             | lb. | 4 50    | 5 00    |
| Resorcin, pure                  | lb. | 7 50    | 8 00    |
| S. Heylic acid                  | lb. | 95      | 95      |
| Solol                           | lb. | 1 50    | 2 00    |
| Sulphanilic acid, crude         | lb. | 31      | 33      |
| Tolidin                         | lb. | 2 50    | 3 00    |
| Tolidine-mixture                | lb. | 85      | 90      |

## Petroleum Oils

Crude (at the Wells)

|                       |      |        |        |
|-----------------------|------|--------|--------|
| Pennsylvania          | bbl. | 4 00   | 4 00   |
| Cleveland, Ohio       | bbl. | 2 60   | 2 60   |
| Somerset, Ky.         | bbl. | 2 60   | 2 60   |
| Wagoner, Ohio         | bbl. | 2 68   | 2 68   |
| Indiana               | bbl. | 2 28   | 2 28   |
| Hillman               | bbl. | 2 28   | 2 28   |
| Oklahoma and Kansas   | bbl. | 2 25   | 2 25   |
| Caddo, La., light     | bbl. | 2 25   | 2 25   |
| Corcoran, Tex., light | bbl. | 2 25   | 2 25   |
| California            | bbl. | 1 24   | 1 57   |
| Gulf Coast            | bbl. | 1 35   | 1 35   |
| Mexican               | bbl. | 1 90   | 1 90   |
| Fuel Oil              |      |        |        |
| New York              | gal. | 15     | 15     |
| Philadelphia          | gal. | 07 1/2 | 15 1/2 |
| Pittsburgh            | gal. | 07 1/2 | 10     |
| Texas                 | bbl. | 1 85   | 2 35   |
| Los Angeles           | bbl. | 1 65   | 1 65   |

## Gasoline (Wholesale)

|                       |      |     |    |
|-----------------------|------|-----|----|
| New York, motor.      | gal. | 244 | —  |
| Gas machine.          | gal. | 241 | —  |
| 72-76 degrees.        | gal. | 333 | —  |
| 70-72 degrees.        | gal. | 32  | 39 |
| 67-70 degrees.        | gal. | 303 | 36 |
| Pittsburgh, motor.    | gal. | 25  | —  |
| Chicago, motor.       | gal. | 224 | 23 |
| Oklahoma, motor.      | gal. | 214 | —  |
| San Francisco, motor. | gal. | 204 | —  |

## Paraffine Waxes

|                               |     |    |    |
|-------------------------------|-----|----|----|
| Crude, 103 to 105 deg. m.p.t. | lb. | 08 | 09 |
| Crude, 118 to 120 deg. m.p.t. | lb. | 09 | 10 |
| Crude, 124 to 126 deg. m.p.t. | lb. | 10 | —  |
| Refined, 120 deg. m.p.t.      | lb. | 13 | —  |
| Refined, 128 deg. m.p.t.      | lb. | 14 | —  |
| Refined, 135 deg. m.p.t.      | lb. | 16 | 16 |
| Ozokerite, brown.             | lb. | 75 | —  |
| Ozokerite, green.             | lb. | 85 | —  |

## Lubricants

|                                              |      |    |    |
|----------------------------------------------|------|----|----|
| Black, reduced, 29 gravity, 25-30 cold test. | gal. | 24 | 25 |
| Cylindor, light.                             | gal. | 45 | 50 |
| Cylindor, dark.                              | gal. | 39 | 43 |
| Paraffine, high viscosity.                   | gal. | 40 | 41 |
| Paraffine, 303 sp. gr.                       | gal. | 36 | 38 |
| Paraffine, 885 sp. gr.                       | gal. | 26 | 28 |

## Flotation Oils

(Prices at New York unless otherwise stated)

|                                                                     |      |    |    |
|---------------------------------------------------------------------|------|----|----|
| Pine oil, crude, f. o. b. Florida                                   | gal. | 44 | —  |
| Pine oil, steam-distilled, sp. gr. 0.925-0.940                      | gal. | 58 | 60 |
| Pine oil, destructively distilled                                   | gal. | 58 | 60 |
| Pine-tar oil, sp. gr. 1.07-1.035                                    | gal. | 35 | —  |
| Pine-tar oil, double refined, ap. gr. 0.965-0.990                   | gal. | 42 | —  |
| Pine-tar oil, ref., light, sp. gr. 0.950, tank cars, f. o. b. works | gal. | 37 | —  |
| Pine-tar oil, ref., heavy, sp. gr. 1.025, tank cars, f. o. b. works | gal. | 28 | —  |
| Pine-tar oil, ref., thick, sp. gr. 1.060-1.080                      | gal. | 32 | —  |
| Turpentine, crude, ap. gr. 0.870-0.900                              | gal. | 45 | —  |
| Hardwood oil, f. o. b. Michigan, ap. gr. 0.960-0.990                | gal. | 23 | —  |
| Hardwood oil, f. o. b. Michigan, sp. gr. 1.06-1.08                  | gal. | 31 | —  |
| Wood creosote, ref. f. o. b. Florida                                | gal. | 31 | —  |

## Naval Stores

|                                           |               |       |       |
|-------------------------------------------|---------------|-------|-------|
| Rosin A-E barrel.                         | 280 lb.       | 14.50 | 15.10 |
| Rosin F-I                                 | 280 lb.       | 15.10 | 15.40 |
| Rosin K-N                                 | 280 lb.       | 15.75 | 16.25 |
| Rosin W-G-W                               | 280 lb.       | 16.25 | 16.60 |
| Spirits of turpentine.                    | gal.          | 67    | —     |
| Wood turpentine, steam distilled.         | gal.          | 63    | —     |
| Wine turpentine, destructively distilled. | gal.          | 58    | —     |
| Pitch                                     | bbbl. 200 lb. | 7.50  | —     |
| Tar, kiln dried.                          | 280 lb.       | 12.50 | —     |
| Retort tar.                               | 280 lb.       | 13.50 | —     |
| Rosin oil, first run.                     | gal.          | 74    | —     |
| Second run.                               | gal.          | 77    | —     |
| Third run.                                | gal.          | 82    | —     |
| Fourth run.                               | gal.          | 92    | —     |

## Vegetable Oils

|                           |      |      |      |
|---------------------------|------|------|------|
| Castor oil                | lb.  | 28   | 30   |
| China wood oil.           | lb.  | 29   | 30   |
| Cocoon oil.               | lb.  | 17   | 21   |
| Corn oil.                 | lb.  | 18   | —    |
| Cottonseed oil, crude.    | lb.  | 20   | 22   |
| Linseed oil, raw, cars.   | gal. | 1.84 | 1.90 |
| Olive oil.                | gal. | 4.25 | 4.50 |
| Peanut oil, crude.        | lb.  | 18   | 22   |
| Soya bean oil, Manchuria. | lb.  | 16   | 18   |

## Glues

|                            |      |      |      |
|----------------------------|------|------|------|
| Extra white.               | lb.  | 36   | 45   |
| Cabinet.                   | lb.  | 31   | 40   |
| Shoe (foot stock).         | lb.  | 19   | 22   |
| Fish glue, 50-gal. barrels | gal. | 1.00 | 1.00 |

## Miscellaneous Materials

|                                      |         |       |       |
|--------------------------------------|---------|-------|-------|
| Barytes, floated, white, foreign.    | ton     | 38.00 | 42.00 |
| Barytes, floated, white, domestic.   | ton     | 33.00 | 36.00 |
| Beeswax, white, pure.                | ton     | 60    | —     |
| Beeswax, unbleached.                 | lb.     | 43    | 48    |
| Blane fix                            | lb.     | 05    | —     |
| Casio                                | lb.     | 174   | —     |
| Ceylon graphite.                     | lb.     | 25    | 28    |
| Chalk, light, precipitated, English. | lb.     | 044   | 06    |
| China clay, imported, lump.          | ton     | 20.00 | 40.00 |
| China clay, domestic, lump.          | ton     | 15.00 | 22.50 |
| Feldspar.                            | ton     | 12.00 | —     |
| Fluorspar, gravel, f. o. b. mines.   | ton     | 60.00 | —     |
| Fluorspar, washed, powdered.         | ton     | 90.00 | —     |
| Gull's earth, powdered.              | 100 lb. | 1.50  | 2.00  |
| Japan wax.                           | ton     | 75.00 | 78    |
| Mexican graphite.                    | ton     | 10    | 15    |
| Madagascar graphite.                 | lb.     | 10    | 15    |
| Orange shell.                        | lb.     | 72    | 78    |
| Pumice stone.                        | lb.     | 08    | —     |
| Red lead, dry, carloads.             | 100 lb. | 112   | 113   |
| Soapstone.                           | ton     | 15.00 | 25.00 |
| Sourie's acid, 120 deg. m.p.t.       | lb.     | 18    | —     |
| Sourie's acid, 140 deg. m.p.t.       | lb.     | 19    | —     |
| Talc, American, white.               | ton     | 20.00 | 40.00 |
| White lead, dry.                     | lb.     | 094   | 104   |

## Refractories, Etc.

(F. O. B. Works)

|                                   |          |        |        |
|-----------------------------------|----------|--------|--------|
| Chrome brick.                     | net ton  | 175.00 | —      |
| Chrome cement.                    | net ton  | 75.00  | —      |
| Clay brick, 1st quality fireclay. | per 1000 | 50.00  | 55.00  |
| Clay brick, second quality.       | per 1000 | 35.00  | 40.00  |
| Magnesite, raw.                   | ton      | 30.00  | 35.00  |
| Magnesite, calcined, powdered.    | ton      | 50.00  | 65.00  |
| Magnesite, dense burned.          | net ton  | 50.00  | 60.00  |
| Magnesite brick, 9x4x2 1/2.       | net ton  | 110.00 | 125.00 |
| Silica brick.                     | per 1000 | 50.00  | 60.00  |

## Ferroalloys

|                                                     |     |        |        |
|-----------------------------------------------------|-----|--------|--------|
| Ferrocobaltitanium, 15-18 per cent, carloads.       | ton | 200.00 | 250.00 |
| F. o. b. Niagara Falls, N. Y.                       | lb. | 15.00  | 30.00  |
| Ferrocobalt.                                        | lb. | 30     | 40     |
| Ferrocromium, per lb. of Cr.                        | ton | 250.00 | —      |
| Ferromanganese, domestic, 70 per cent basis.        | ton | 325.00 | —      |
| Ferromanganese, English.                            | ton | 75.00  | —      |
| Spiegel (16-18%)                                    | lb. | 4.00   | 4.50   |
| Ferromolybdenum, per lb. of Mo.                     | ton | 180.00 | 190.00 |
| Ferroallic, 75 per cent, f. o. b. N. Y.             | ton | 160.00 | 170.00 |
| Ferroallic, 50 per cent, carloads, del. Pittsburgh. | lb. | 2.35   | 2.40   |
| Ferrotungsten, 75-85 per cent, f. o. b. Pittsburgh. | lb. | 7.50   | —      |
| Ferrovandium, f. o. b. works, per lb. of U.         | lb. | —      | —      |

## Ores and Semi-finished Products

|                                                          |      | Nominal |        |
|----------------------------------------------------------|------|---------|--------|
| Antimony ore, per unit.                                  | ton  | 1.50    | 1.55   |
| Chrome ore, 45 per cent minimum, f. o. b. Cal. per unit. | ton  | 1.40    | —      |
| Chrome ore, 45 per cent and over, New York, per unit.    | ton  | 1.20    | —      |
| Manganese ore, 48 per cent and over, per unit.           | ton  | 80.00   | 100.00 |
| Manganese ore, chemical.                                 | lb.  | 1.25    | —      |
| Molybdenite, per lb. of MoS <sub>2</sub> .               | ton  | 25.50   | —      |
| Tungsten, Scheelite, per unit of WO <sub>3</sub> .       | ton  | 24.00   | —      |
| Tungsten, Wolframite, per unit of WO <sub>3</sub> .      | lb.  | 3.25    | 3.60   |
| Uranium oxide, 96%.                                      | lb.  | 10.50   | —      |
| Vanadium pentoxide, 99%.                                 | unit | 17      | 17     |
| Pyrites, foreign.                                        | unit | 28      | 304    |
| Pyrites, domestic.                                       | unit | —       | —      |

## Plant Supplies

## BUILDING MATERIALS

|                                          |         |        |        |
|------------------------------------------|---------|--------|--------|
| Common clay bricks.                      | M       | 13.00  | 14.00  |
| Hollow tile, 4 x 12 x 12.                | M       | 60.00  | —      |
| Hollow tile, 12 x 12 x 12.               | M       | 170.00 | —      |
| Portland cement.                         | ton     | 2.50   | —      |
| Single glass (82-lb.), 10 x 26-16 x 24.  | bbbl.   | 21.00  | 27.00  |
| Double glass (164 lb.), 10 x 26-16 x 29. | ton     | 31.00  | 39.00  |
| Yellow pine lumber.                      | M       | 29.00  | 45.00  |
| Fir lumber.                              | M       | 38.00  | 53.00  |
| Hemlock.                                 | M       | 24.50  | 40.00  |
| Tarred felt (14-lb.-sq.).                | ton     | 68.00  | —      |
| Roofing pitch.                           | ton     | 27.00  | —      |
| Asphalt coated roofing (35-55-lb. sq.).  | sq.     | 1.60   | 2.45   |
| State surfaced asphalt shingles.         | sq.     | 5.25   | 5.50   |
| Corrugated galvanized iron.              | ton     | 109.00 | 127.00 |
| Red oxide (Ppte. Copperas).              | 100 lb. | 15.00  | 20.00  |
| Native red oxide.                        | 100 lb. | 3.25   | 8.00   |
| Red metallic paint.                      | 100 lb. | 1.20   | 1.50   |
| White lead in oil.                       | 100 lb. | 11.84  | 14.00  |
| Red lead in oil.                         | 100 lb. | 12.28  | 14.50  |
| Zinc oxide (dry).                        | 100 lb. | 13.00  | 14.50  |
| Zinc oxide—leaded.                       | 100 lb. | 9.00   | 10.00  |
| Yellow ochre.                            | 100 lb. | 15.00  | 10.00  |
| Ultra marine blue.                       | 100 lb. | 1.00   | 50.00  |
| Prussian blue.                           | 100 lb. | 135.00 | 150.00 |
| Chrome green.                            | 100 lb. | 40.00  | 70.00  |
| Paris green.                             | 100 lb. | 43.00  | 49.00  |
| Mineral black.                           | 100 lb. | 1.75   | 2.25   |
| Powdered bone black.                     | 100 lb. | 5.50   | 12.00  |
| Lampblack.                               | 100 lb. | 15.00  | 45.00  |
| Gas carbon.                              | 100 lb. | 16.00  | 25.00  |
| Mexican petroleum pitch.                 | 100 lb. | 1.00   | 2.00   |
| Gileonite.                               | 100 lb. | 2.00   | 2.50   |
| Coal tar pitch.                          | 100 lb. | 40     | 1.00   |

## STRUCTURAL IRON

|                                    |     |        |        |
|------------------------------------|-----|--------|--------|
| Blue annealed sheet iron.          | ton | 84.00  | 89.00  |
| Black sheet iron.                  | ton | 96.00  | 104.00 |
| Galvanized iron.                   | ton | 105.00 | 170.00 |
| Tern plate, 8-lb. coating.         | ton | 150.00 | —      |
| Tern plate, 15-lb. coating.        | ton | 172.50 | —      |
| Tern plate, 25-lb. coating.        | ton | 200.00 | —      |
| Tern plate, 40-lb. coating.        | ton | 240.00 | —      |
| Tin plate, prime.                  | ton | 15.00  | —      |
| Tank plates.                       | ton | 65.00  | 70.00  |
| Beams, channels, angles, T's, Z's. | ton | 60.00  | 65.00  |
| Rivets.                            | ton | 88.00  | 92.00  |
| Steel pipe, 4 to 3-inch.           | ton | 51.00  | —      |
| Bar iron and steel.                | ton | 60.00  | 70.00  |
| Chain (1 inch proof coil).         | ton | 150.00 | —      |
| Nails, bolts, nuts, washers.       | ton | 70.00  | 80.00  |
| Tool steel, special alloys.        | ton | 300.00 | 500.00 |
| Bessemer pig iron.                 | ton | 47.50  | —      |
| Bessemer steel.                    | ton | 47.50  | —      |
| No. 2 foundry.                     | ton | 33.50  | —      |
| Steel billets (4 x 4).             | ton | 47.50  | —      |

## POWER HOUSE SUPPLIES

|                               |     |      |     |
|-------------------------------|-----|------|-----|
| Steam packing, rubber duck.   | lb. | 99   | 110 |
| Asbestos, high pressure.      | lb. | 1.76 | —   |
| Asbestos, wired.              | lb. | 1.30 | —   |
| Asbestos, grapted braid.      | lb. | 1.21 | —   |
| Asbestos, wick.               | lb. | 75   | —   |
| Rubber, sheet.                | lb. | 66   | —   |
| Cup grease.                   | lb. | 07   | —   |
| Transmission grease.          | lb. | 04   | —   |
| Axle grease.                  | lb. | 044  | —   |
| Gear grease.                  | lb. | 041  | —   |
| Cotton waste.                 | lb. | 084  | —   |
| Hose, underwriters, 2 1/2 in. | ft. | 30   | 60  |
| Hose, air, 1 in.              | ft. | 30   | 60  |

# INDUSTRIAL NEWS

## Plant Construction—Catalogs—New Publications

### Construction and Operation

#### Arizona

**KINGMAN.**—The Standard Mineral Co. will build a 50-ton flotation mill in the Mainard Mining District. Estimated cost, \$40,000. Ray L. Connell, engineer.

#### Arkansas

**MENA.**—The Baby Ray Mining Co., Room 11, Turner Building, Tulsa, Okla., is in the market for a steam shovel, log washer, belts, lumber, concrete, roofing, pumps and pipe. Estimated cost, \$25,000.

**ROGERS.**—Mr. George Pollard and Dr. Frank Schuckles will build a concentration plant and smelter for platinum and are in the market for engine, boilers, motors, pipe, pump, sludge and slime tables, crushers, lumber, concrete, belts, conveyors, tracks, ore cans, ore cars, smelter machinery or any, belts, lumber, steel sides and metal roofing. Estimated cost, \$80,000.

**ZELLVILLE.**—The Cowan-Banners Development Co. will build a 200-ton concentration plant, and is in the market for sludge and slime tables, crushers, air compressors, drills, ore cans, ore cars, belts, engine, boilers, lumber and concrete. Estimated cost, \$60,000.

#### Connecticut

**STRATFORD.**—The Raybester Co., 1427 Railroad Ave., Bridgeport, has awarded the contract for the erection of a one and one half story, 100 x 105 ft., brick and concrete factory, to J. R. Sheehan, 211 State St. Estimated cost, \$17,000.

#### Florida

**FORT LAUDERDALE.**—The city will install a water filtration plant. Address the Mayor.

**JACKSONVILLE.**—The Jacksonville Gas Co., Laura and Church St., received low bid for building a 2-story, steel gas plant, from H. Vesey, \$12,500.

**MOORE HAVEN.**—The Grass Fiber Paper Pulp Co., recently incorporated with \$150,000 capital, has leased 75,000 acres of saw-grass land and will build a plant to manufacture paper from saw-grass.

#### Illinois

**CHICAGO.**—The Union Stock Yards, 38 South Dearborn St., will build a 6-story, 32 x 70 ft. rear addition to its soap boiling building. J. H. Jilison, c/o owner, architect.

#### Indiana

**GARY.**—United States Government plans to purchase from 2000 to 3000 acres of land near here, on which to build an air nitrate plant.

#### Kansas

**BAXTER SPRINGS.**—The Miami Volunteer Mining Co. will build a 200-ton concentration plant and is in the market for sludge and slime tables, crushers, air compressors, conveyors, engine, boilers, lumber, roofing, etc. Estimated cost, \$65,000. J. L. Hawthorne, superintendent.

#### Louisiana

**MONROE.**—The city will build a filtration plant. Estimated cost, \$25,000. W. G. Kirkpatrick, Jackson, Miss., engineer.

#### Maryland

**BALTIMORE.**—The General Chemical Co., 1218-24 Munsey Building, has awarded the contract for the erection of a 3-story, 153 x 213 ft., concrete brick and steel chemical plant addition on Race and Winder St., to the Westinghouse, Church, Kerr & Co., 37 Wall St., New York City, N. Y. Estimated cost, \$155,000. J. M. Bellamy, manager.

**BALTIMORE.**—The Kennedy Foundry Co., Charles and Wells St., will build a concrete and brick addition to its plant, and is in the market for moulding machinery for the manufacture of mustard gas shells of semi-steel for the United States

Government. Total estimated cost, \$100,000.

**HAGERSTOWN.**—The Central Chemical Co., Thomas Building, has increased its capital stock from \$200,000 to \$600,000 and will build additions to its plant.

**INDIAN HEAD.**—The Bureau of Yards and Docks, Navy Department, Washington, D. C., received low bids for an oxidation absorption building, from the De Keni Construction Co., Dispatch Building, Union Hill, N. J., \$124,000; Austin Co., 1313 H. St., Washington, D. C., \$143,000; Chemica Construction Co., Tyron St., Charlotte, C., \$175,500.

#### Massachusetts

**SPRINGFIELD.**—The Hendee Manufacturing Co., 837 State St., has awarded the contract for the erection of a 1- and 2-story, 60 ft. pipe boiler plant and a 60 x 87 ft. hardening room, reinforced concrete, brick and steel, to E. J. Pinney, 264 Main St. Estimated cost, \$37,000.

#### Michigan

**GRAND RAPIDS.**—The Imperial Chemical Co., Ann St., will extend and improve its plant to provide for increased capacity.

#### Missouri

**GRANBY.**—Heaton & Hodges, Neosho, will build a 500-ton concentration plant and is in the market for two crushers, six sludge and slime tables, conveyors, air compressors, lumber, concrete, motors, engine, belts, pipe, roofing, bins, scales, cables, jigs, ore cans, ore cars and drills. Estimated cost, \$100,000. W. Heaton, superintendent.

**MACON.**—The city will build a sewage disposal plant, including Imhoff tank, sludge bed and storm overflow, involving about 790 lin. 18-in. sewer and straightening of creek channel. Frank L. Wynn, Syndicate Building, St. Louis, Mo., engineer.

**NEOSHO.**—The Neosho Mining Co. will build a 150-ton concentration plant near Spurgeon, and is in the market for crushers, boilers, engines, pipe, air compressors, concrete, lumber, roofing, conveyors, belts and wire cables. Estimated cost, \$340,000. C. Bushner, superintendent.

**ST. LOUIS.**—The LaCade Gas Light Co., 11th and Olive St., has awarded the contract for the erection of a 1-story, 200 x 1200 ft. steel plant for the manufacture of munition, to Austin Co., 1212 Euclid Ave., Cleveland, Ohio. Estimated cost, \$8,000,000. Noted Aug. 31.

**ST. LOUIS.**—The Pan Electric Manufacturing Co., 735 South 4th St., plans to build a 60 x 100 ft. administration building and laboratories. Estimated cost, \$50,000. W. C. Forder, in charge.

**ST. LOUIS.**—The R. & N. Kansas Limestone Co., Joplin, will build a 250-ton jig and concentration plant, and is in the market for four hand jigs, crushers, bins, pipe, lumber, cement, roofing, drills, engine, boilers, air compressors, belts, conveyors, car, track, cans and sludge tables. Estimated cost, \$65,000. W. A. Meese, superintendent.

#### New Hampshire

**NASHUA.**—The Nashua Manufacturing Co. has awarded the contract for the erection of a 5-story, 80 x 27 ft. reinforced concrete dye house, to the Turner Construction Co., 244 Madison Ave., New York City, N. Y.

#### New Jersey

**BLOOMFIELD.**—The International Arms & Fuse Co., Grove St. and Bloomfield Ave., will build a 1-story, 20 x 190 ft. heat treating shop addition to its existing works. Estimated cost, \$20,000.

**CAMDEN.**—The Dobbins Soap Manufacturing Co., Federal St., will build an addition to its plant and make alterations and improvements to its existing works. Estimated cost, \$20,000.

**CHROME.**—The American Agriculture Chemical Co. has awarded the contract for the erection of a 2-story, 101 x 227 ft. reinforced concrete fertilizer plant, to its Cable Works here, to the Turner Construction Co., 244 Madison Ave., New York City, N. Y.

**TRENTON.**—The M. M. S. Metal Co., Fall St., will rebuild its plant recently damaged by fire, entailing a loss of \$25,000.

#### New York

**BUFFALO.**—The Metal & Alloy Specialty Co., 25 Illinois St., will build a 2-story, 60 x 100 ft. brick and steel factory at Marion Ave. and New York Central Railroad. Elmer Rac, manager.

**CARTHAGE.**—The National Paper Co., 126 Canal St., will build a 3-story, 60 x 200 ft. concrete and brick paper mill. Estimated cost, \$60,000.

**ELIOT.**—The Hemington Arms Co. has awarded the contract for the erection of 2-story, 70 x 197 ft. dry kiln, to Richards & Co., 246 Elizabeth St., Utica. Estimated cost, \$35,000.

**NEW YORK CITY.**—The Goodyear Rubber Insulating Co., 105 East 131st St., will build a 2-story addition to its plant here.

**OSWEGO.**—The Hessler Foundry & Manufacturing Co., Mitchell St., will rebuild its plant which was recently destroyed by fire entailing a loss of \$100,000. The company manufactures brass and castings. C. J. Hessler, president.

**PIERMONT.**—The Piermont Paper Mills has awarded the contract for the erection of a 2-story, 100 x 250 ft. reinforced concrete structure, to Turner Construction Co., 244 Madison Ave., New York City, N. Y.

#### Ohio

**AKRON.**—The Kelly Springfield Tire Co., 229 West 57th St., New York City, N. Y., has awarded the contract for the erection of a 3-story, 40 x 130 ft. concrete, brick and steel rubber factory, to W. A. Franklin & Sons, 146 Howard St. Estimated cost, \$50,000.

**CLEVELAND.**—The National Carbon Co., West 117th St., has awarded the contract for the erection of six 1-story buildings, three 50 x 60 and three 60 x 80 ft. reinforced concrete, brick and steel, to the Hukin Conkey Co., Century Building. Estimated cost, \$100,000.

**CLEVELAND.**—The Ordnance Department, United States Government, Plymouth Building, Prospect and East 22nd St., will build a byproduct coke oven. Estimated cost, \$500,000.

**KINGS MILLS.**—The Peters Cartledge Co., 1700 Federal Bank Building, Cincinnati, will build a 2-story concrete brick and steel factory for the manufacture of munitions. Estimated cost, \$50,000.

**LORAIN.**—The Union Chemical Co., Union Building, Cleveland, has awarded the contract for the erection of eighteen, 1- and 2-story, reinforced-concrete, brick and steel chemical plants, to J. Hott & Co., C. Bushner, superintendent.

**MIDDLETOWN.**—The Paul Sorg Paper Co. has awarded the contract for the erection of a 2-story, 25 x 288 ft. brick, steel and reinforced concrete building, to Caldwell & Iseninger, 5th St. Estimated cost, \$60,000.

**ARDMORE.**—The Choctaw Refining Co., Carter Building, will build an oil refinery for the production of lubricating oil and wax, and will install oil refinery equipment etc. R. W. Wallace engineer.

#### Oklahoma

**DOUTHAT.**—The Suening Mining Co. will build a 250-ton concentration plant and is in the market for sludge and slime tables, crushers, conveyors, motors, lumber, roofing, concrete, engine, boilers, air compressors, pumps, pipes, cables and jigs. Estimated cost, \$65,000. J. Pulver, superintendent.

**DUNCAN.**—The city will build sewage disposal plant. Estimated cost, \$30,000.

**KANSAS.**—The Peabody Mining Co., Joplin, Mo., will build a 200-ton concentration plant and is in the market for crushers, sludge and slime tables, belts, cables, engine, boilers, air compressors, engines, lumber, concrete, ore cans and ore cars. Estimated cost, \$65,000. J. H. Wright superintendent.

**LINCOLNVILLE.**—The Lucky Pat Mining Co., Miami, will build a 200-ton concentration plant near here and is in the market for jigs, crushers, rolls, drills, air compressors, lumber, conveyors, engine, boilers, roofing, pumps, pipes, cables and slime tables. Estimated cost, \$65,000. J. Screener, superintendent.

**LINCOLNVILLE.**—The Nell Mining Co. will build a 400-ton concentration plant, and is in the market for lumber, roofing, crushers, slime and sludge tables, engine, boilers, motors, belts, drills, ore cans, ore car, wire cables. Estimated cost, \$40,000.



THE BOOTH-HALL COMPANY, Chicago, electric furnace builders and metallurgists, have moved their sales and administrative offices from 565 West Washington Boulevard to 2309 Archer Avenue, where only the engineering and construction departments have heretofore been located. By this change all departments of the business are combined and the furnaces in course of construction are at all times under the inspection of the officials of the company.

# CHEMICAL & METALLURGICAL ENGINEERING

A consolidation of ELECTROCHEMICAL & METALLURGICAL INDUSTRY and IRON & STEEL MAGAZINE

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### The Fourth Liberty Loan and Victory

SIX weeks ago we hazarded the opinion that the Fourth Liberty loan would be a victory loan. Events since that time have only strengthened that opinion. There is danger, however, that optimism will lead to procrastination in seeing the fourth loan through to a successful finish in the allotted time. It should be realized that if peace came tomorrow we have governmental obligations for billions of dollars that would necessitate the flotation of the loan. Victory may be in sight, and we hope it is, but we feel it necessary to caution against lethargy in supporting the Government at this time. Germany's ninth tyranny loan is likely to fail in the face of the disaster confronting her arms, but nothing should be allowed to slacken our pace or weaken our purpose with victory in sight. Failure to "double the third" in the campaign period would strengthen the morale of the enemy and give him cause for renewed hope. It would weaken and discourage our own troops who would be utterly unable to comprehend such a failure in the light of their own accomplishments. We cannot afford to fail, and we are confident we will not; but we believe emphasis should be laid on the magnitude of the undertaking and the necessity of redoubled effort on the part of all if success is to be our reward. We want to be able to say that we fought while they fought, and that we kept at it as long as they did.

### A Reconstruction Commission Should Be Appointed Immediately

THE American Electrochemical Society is the first of the national scientific and engineering societies to consider formally the post-war future of the industry which it represents. Elsewhere in this issue will be found a comprehensive report of the symposium on electrochemical industry in the United States after the war, as presented and discussed at the recent meeting of the Society. It directs our attention to the great necessity which has existed for months past for a national movement to prepare for the reconstruction of our industrial organization and its readjustment to peace conditions. Some time ago CHEMICAL & METALLURGICAL ENGINEERING, in common with all McGraw-Hill engineering publications, proposed a commission to be appointed by the President, to devote its entire time and energies to the reconstruction problem. The subject was considered in detail, and the foundation was laid for the organization. There was no immediate response; but recently we have noted urgent appeals for national attention to the problem, and the introduction of several bills in Congress providing for commissions



to arrange for the transition of our industries.

The United States cannot act too soon. We have pointed out before that the other belligerent nations have long since had their commissions at work; that every other nation of importance has made more progress than we in formulating its problems and discovering their solution. We have been as slow to comprehend post-war conditions as we were to enter the conflict. But conditions in the two instances are different: there was someone to battle for us until we got our fighting clothes on, but there will be none to solve our problems when the conflict is over. Each nation will then be busy with its own affairs, and properly so.

There are two types of commission that can be created to study and handle the matter, one legislative and the other executive. We are unqualifiedly in favor of the latter. Legislative commissions are notoriously inefficient. They have a political cast and a political point of view. Their responsibility is indefinite, their qualifications doubtful. In legal talent they abound, but it is questionable whether they comprehend the problems of employment, production, distribution, and foreign and domestic commerce. A commission of executive appointment, on the other hand, could be created with a special view to its fitness for the great task. Leaders of industry and labor, economists and engineers, experts and specialists could be drafted by the President for such a commission. Its responsibility would be definite, its purpose unhampered by political considerations. Its findings would be guide-posts for industry. We understand that bills for both types of commission have been introduced in Congress. We express the hope that no legislative commission will ever be created, but that one of executive character will speedily come into being. The events of the past few days shows how near the end of the war may be; and the nearer the end, the farther we are from solving our problems.

## A Call to

### Save Paper

**P**ROBABLY one of the most thoughtless wastes in our daily life is the destruction of paper—newspaper and wrapping paper in the home, envelopes and writing paper at the office, magazines everywhere. Ordinarily this waste has passed unheeded, but today we look behind the product of the paper mill to the supplies needed for manufacture, and we visualize paper in terms of coal for power, caustic soda for pulp, chlorine for bleaching, and man-power for operation of the plant. All these commodities are needed for war service in the most direct manner, and consequently they are rationed to the paper industry. Paper, in turn, is rationed to those who buy from the mills. But it is a material of universal use, and its conservation becomes a duty incumbent on the most humble consumer. Methods of conservation are simple and obvious if we but stop and think. Ordinarily but one surface of a sheet of writing paper is used, and while we cannot endorse the universal practice of writing on both sides, we believe there is a big opportunity for saving there. Envelopes can be used for scratch paper, and large manila envelopes can be used over and over again by the simple expedient of pasting a new address over the old one. Waste paper of all kinds can be salvaged and sold to dealers.

## Deterioration of

### Reinforced Concrete

**S**OME time ago the U. S. Bureau of Standards reported the action of electric current on iron bars embedded in concrete. Layers of iron oxide formed at the anode with an accompanying expansion in volume of 220 per cent of the iron oxidized, which gave rise to a mechanical pressure sufficient to crack the concrete. At the cathode the concentration of sodium and potassium had a softening effect on the concrete, which became brittle and friable. Elsewhere in this issue, an excellent account is given of several cases of serious structural deterioration due to the corrosion of the reinforcing bars in the presence of salts. The origin of the electromotive force may be assigned to several causes but great differences in concentration of the electrolyte due to evaporation of the solution at the surface of the concrete may exert a considerable proportion of the potential. Exhaustive studies of this corrosion are being made. It is fundamental to modern engineering practice that means for overcoming it should be found at once. The domains of the chemical and civil engineers overlap here and it is incumbent on the former to use his most efficient research methods and find the solution of the problem.

Ordinary rust-proofing methods are not available except for a limited use of paint, which has certain serious defects. Less porous concrete can certainly be had by proper control of the batch mixes—the water content being the most abused. Allowance should also be made for actual drainage of the liquid portions from the aggregate—the 1:2:4 etc. rule being too limited for supplying the varying requirements found in actual practice. Honeycombed pours are not rare and subsequent plastering-over neither protects the metal reinforcements from the weathering agencies nor does more than deceive the observer as to its quality. The addition of mineral soaps and oils on a large scale would be a serious item of cost in rendering all concrete waterproof. Certain mineral colloids seem to offer an excellent means of cutting down the volume of pore space. However, while chemists and engineers seek a means of checking the corrosion, why not change the design of reinforcements so that this internal pressure will not have to be counteracted by the low tensile strength of concrete? A trial might be made on heavy rolled metal fabricated with a pipe machine but not welded at the lap. Lateral strains produced by the increment in volume of the reinforcements due to rust would be absorbed by deflecting the tubular bars.

## Germany's Finger

### In the Platinum Pie

**E**DITORIAL comment under this caption in our issue for August 15 has been the subject of some criticism, particularly as relating to Mr. Charles Engelhard and his business associates. Needless to say, our opinion then expressed was based on what we believed to be authentic and reliable information. As to that part of our remarks suggesting the possible influence of Mr. Engelhard in fixing the price paid by our Government for some 20,000 ounces of platinum brought from Russia, he himself has already entered a denial which we have published and accepted at its face value.

Since that time we have had an opportunity to gain



additional information from sworn statements of Mr. Engelhard, in which he disclosed the details of his relations with the German house of Heraeus and the former interest of Heraeus in the American Platinum Works and Baker & Co. These affidavits show that the German interest in these American platinum corporations, as represented by Heraeus, amounted at one time to 20 per cent, but that about April 1916, or nearly one year prior to our declaration of war with Germany, Mr. Engelhard acquired the entire Heraeus interest in the two companies. Since that time it appears that there has been no enemy or ally-of-enemy interest in either of them. We are further advised that Mr. Engelhard has caused a minute to be entered on the records of the several companies in which he is interested, to the effect that he will not reconvey any stock to Dr. Heraeus at the close of the war, without the unanimous approval of all the stockholders of record.

It appears that Mr. Engelhard has been fully investigated on these points, as well as on his entire business career in this country, by several branches of the Government. Unfortunately the Government does not officially announce the results of such investigations nor publicly state its opinion regarding the loyalty of the individuals investigated. As one official explained it to us, the evidence is presumptively in the individual's favor if no action is taken against him. Thus, while we have been unable to secure from any official or agent of the Government any statement as to the result of the investigations, we presume it was favorable to Mr. Engelhard and satisfactory to the Government. Since there was no malice in our original remarks nor any desire to do an injustice to Mr. Engelhard, we are glad to correct any false impression we may have created as to his loyalty or the German control of his companies.

### Coke, Pig Iron and Transportation

PRODUCTION of pig iron in the first half of 1918 is officially reported at 18,227,730 gross tons, which is more than a million tons less than the production in any one of the four preceding half years, and 1,600,000 tons less than the production in the latter half of 1916. The blast-furnace capacity had meanwhile undergone a very considerable increase. The failure in production in the first half of this year was due to shortage of coke and the shortage of coke was due to the railroad breakdown whereby by-product coke production was curtailed materially and beehive coke production curtailed a great deal. All the loss in pig iron production occurred during the first quarter of the year. Production in the second quarter was more than 10,000,000 tons, or at a rate greater than obtained in any preceding half year. Production in the third quarter was substantially the same, and production in the current quarter promises to be much heavier.

The Railroad Administration insists that there is not the least likelihood of a railroad breakdown this winter at all comparable to that of last winter and no doubt the balance of probabilities lies strongly in that direction. The railroads are much better organized, the shipments are much better controlled so that they do not tend to produce congestion as they did a year ago,

and a repetition of last winter's altogether exceptional weather is of course unlikely.

Even though pig iron production conditions have been much less unsatisfactory in recent months than in the first three months of the year they have not been really satisfactory by any means, as the output has not been as much as would be expected from the capacity of the furnaces in blast. A thorough investigation of the matter was undertaken nearly two months ago and the blast furnaces laid most of the blame on the character of the coke they were receiving, there being much coke of poor structure and much coke with too much ash, the former indicating carelessness in burning, the latter carelessness in mining. The Fuel Administration accordingly inaugurated a strenuous campaign to bring about the production of coke of better quality, and some results have lately begun to be apparent.

The importance of coke quality cannot be overestimated. The production of coke has been approximately equal to the requirements of the blast furnaces for months past, the cases of coke shortage being few and far between. Better coke means more pig iron per furnace, and as a total. More pig iron means more steel, for the steel works are not fully supplied with pig iron in relation to their capacity, and every ton of steel helps to win the war. The control of steel by the War Industries Board, rigid for several months and constantly growing more rigid, insures that every additional ton of steel made will be placed where it will do good.

The production of by-product coke has increased even more rapidly than was expected. In this department two months ago there was a survey of the situation as to the completion of by-product ovens, and it was estimated, conservatively, that by the end of the year there would be 615,000 net tons per week rated capacity in by-product coke, which with a 90 per cent efficiency, about what had been shown in the past, would mean an output of 550,000 tons a week. Two months later, however, we have the Geological Survey report for the week ended September 28, showing a rated capacity of 624,910 tons, a production of 576,254 tons, and a proportion of production to rated capacity of 92.2 per cent. This high percentage was probably fortuitous, for every one of the separate causes of loss was exceptionally low—coal shortage, labor trouble, repairs and miscellaneous. In the same week the production of beehive coke was 612,000 tons, making a total of 1,188,000 tons of coke produced in the week, representing a rate of 62,000,000 tons a year.

The normal function of a by-product coking plant is to make coke as a product and certain other things as by-products. That is not precisely the alignment in war time. The Clairton plant in the Pittsburgh district, where seven batteries of 64 ovens each are now in operation, with three more batteries to follow very shortly, is operating on high volatile coal from the Klondike region, when physical conditions would permit the use of the lower volatile coal of the Old Basin, because the output of toluol and sulphate of ammonia is correspondingly increased. On 19 hours' coking time the plant is showing 1,000 tons coal consumption and 650 tons coke production per battery per day. The Old Basin coals run 70 per cent and upwards while the Klondike coals are all well below 70 per cent.

## Readers' Views and Comments

### Effect of Oxygen on Precipitation of Cyanide Solutions

To the Editor of *Chemical & Metallurgical Engineering*

SIR:—In the September 15th issue of *CHEMICAL & METALLURGICAL ENGINEERING*, in the discussion of Mr. Thomas B. Crowe's paper on "The Effect of Oxygen Upon the Precipitation of Metals from Cyanide Solutions," I note that you attribute the following remarks to me:

"Chairman Clevenger said that without endeavoring to detract from Mr. Crowe's work in the least he thought that the same thing had been done inadvertently in vacuum filtering, in the Butter's type machine, for many years."

This statement as it appears could readily be construed as meaning that although unconscious of what they were doing all operators of vacuum filters had removed the air from their cyanide solutions prior to precipitation. Furthermore, it might be assumed that Mr. Crowe's development lacked patentable novelty.

My introductory remarks as taken from the stenographic report of the meeting were as follows:

"I am sure that Mr. Crowe's paper will prove of a great deal of interest to cyanide operators as it is a distinct new development in cyanidation. After reading the paper, it occurred to me that some of us had done practically the same thing sometime ago, but that we had done so without design and unconsciously. I refer particularly to the operation of some of the earlier types of vacuum filter with which was used a dry-vacuum pump and a receiver. This is similar equipment to that employed by Mr. Crowe, and it is obvious that all solution passing through the filter under this condition would have its air removed.

"However, we did not know the good effects that we were getting from such of this solution as was precipitated, and it has remained for Mr. Crowe to bring sharply to our attention the advantages of removing air from cyanide solutions prior to precipitation. I feel sure that we will all give him full credit for this clever improvement in the cyanide process."

During the discussion the further observation was made:

"It is the case of one of those obviously simple things when you see it in operation, yet something that we have all overlooked despite the fact that we have operated vacuum filters."

It will be noted that I referred particularly to the operation of some of the earlier types of vacuum filters with which was used a dry-vacuum pump and receiver. As a matter of fact the dry-vacuum pump and receiver were discontinued for later installations in favor of the wet-vacuum pump, on account of the greater simplicity of the arrangement, there being required no receiver, and so-called barometric leg for continuously discharging the solution from the receiver without breaking the vacuum.

It is obvious that in installations employing the wet-vacuum pump little or no air would be removed from the solution. In installations employing the dry-vacuum pump the air was removed only from such solution as passed the filter. In the operation of filters of all types it has been long recognized that thick pulp can be most efficiently filtered; or, in other words, the smaller the proportion of the solution which it is necessary to force through the filtering medium in forming the

cake, the greater the capacity of a given unit. The whole of the pregnant solution precipitated was, therefore, never passed through the filter. Practice regarding the proportion of solution from the filter which was precipitated varied. In many cases the amount of such solution precipitated was small, and in some cases none of it was precipitated.

On the whole it is, therefore, clear that in vacuum filtration as practiced in recent years, no benefit has been derived through the removal of air from solutions passing the filter.

Mr. Crowe has been the first to point out that it was advantageous to remove dissolved air from pregnant solutions prior to precipitation, and acting upon this knowledge he has been the first to apply a vacuum to all the pregnant solution prior to precipitation. Therefore, there can be no question regarding the originality of his invention.

G. H. CLEVINGER.

Colorado Springs, Colo.

### Germany's Finger in the Platinum Pie

To the Editor of *Chemical & Metallurgical Engineering*

SIR:—Our attention has been called to the editorial in your issue of August 15, entitled "Germany's Finger in the Platinum Pie" and we wish to protest against the statements made therein so far as concerns our firm.

As you may know, we have acted as agents for the British Government in regard to platinum during the war.

Your statement that "Heraeus also is said to have owned a one-fifth interest in Johnson Matthey & Co.," is wholly incorrect. Neither Heraeus, nor any German individual, partnership or corporation owns or at any time has owned any interest whatsoever in Johnson Matthey & Co. Our stock is and has always been held exclusively by British proprietors.

JOHNSON MATTHEY & CO., LTD.

London, England.

### Chemical Questionnaire Not a Call to Service

To the Editor of *Chemical & Metallurgical Engineering*

SIR:—General Sibert directs me to extend to you the thanks of the Chemical Warfare Service of the United States Army for your assistance in the census of American chemists recently made by this arm of the service. Without the aid of your journal it would have been impossible to have gained such wide publicity for the enterprise, or to have obtained such a prompt and altogether satisfactory response from the great body of loyal chemists of this country. Well over half the questionnaires have been answered within the first three weeks of the campaign, and the rest are daily being received in such numbers as to indicate the completion of the task at a not far distant date. The War Department is thus put in possession of an invaluable set of records at extremely small expense.

While the purpose of the questionnaire has been understood by nearly all of those who have replied to it, there have been a few instances in which it has been mistaken-

ly interpreted as a call to immediate service. In order to avoid any misunderstanding it should be explained that the purpose of the census is primarily to put the War Department in control of complete information as to the chemical man-power of the country, not to gain immediate recruits for the Chemical Warfare Service. At the present time the vacancies in the Service are comparatively few in number. When vacancies occur in the future, reference will be had to the tabulated information gleaned from the present census, and appointments will be made from the names on file, attention being paid to the applicant's technical qualifications, desire to serve, etc.

The great majority of American chemists will undoubtedly never be called upon to serve in a military capacity in the present war. The Government, however, must have complete information concerning all chemists, in order that it may select those best fitted to perform its work, and at the same time interfere as little as possible with established essential industries. The chemist who, after returning his completed questionnaire, receives no call to service may take it for granted that the Government cannot, for the time being, utilize his services. In the meantime three things are asked of him:

1. To keep the Chemical Warfare Service informed of any change in his address, his employment, his draft status or anything else which might have a bearing on his case.

2. To notify the Chemical Warfare Service at once if he is drafted and called to camp. In such a case he should give his complete military address.

3. To help stabilize the industry of the country by continuing steadily at essential work until the Government notifies him that his services are needed elsewhere.

In addition it is requested that all persons send to the Chemical Warfare Service the names and addresses of any chemists of their acquaintance who have not already received the questionnaire. Chemists who have already received the questionnaire but who have not yet returned it should do so at once, in order that the Government may not be put to the trouble of sending out a large number of follow-up letters. Any chemist who has not received the questionnaire should write for a copy, addressing his request to the Personnel Section, Administration Division, Chemical Warfare Service, U. S. A., 7th and B Streets, N.W., Washington, D. C.

F. E. BREITHUT,

Major Chemical Warfare Service,  
Chief of Personnel.

Washington, D. C.

## Refractory Tube Made in the Laboratory

*To the Editor of Chemical & Metallurgical Engineering*

SIR:—A research chemist of the writer's acquaintance recently found it necessary to use a refractory tube of dimensions not carried in stock by any of the dealers of his locality. Being put to the necessity of making what he wanted he proceeded as follows:

Calined fire-clay ground to pass a fifty-mesh screen was mixed to a paste of such consistency that it could be poured with difficulty. An iron pipe of the desired dimensions was filled with this clay and after shaking until the clay was thoroughly stuck to the pipe the excess was poured out. The pipe was then placed in a

horizontal position and turned slowly until the clay was set. This required but a few minutes. When the clay was set the pipe was attached to an aspirator and a gentle current of air was drawn through the pipe until it was dry; it was then placed in the furnace and burned at the proper temperature, when it was ready for use. This pipe gave perfect satisfaction and was good for any temperature to the melting point of iron. The lining was used to protect the iron from the materials used in the experiment.

JOHN C. BAILAR.

Golden, Colo.

## Removing Plugs from Steel Drums

*To the Editor of Chemical & Metallurgical Engineering*

SIR:—Frequently the threaded plugs in steel drums, especially those containing corrosive chemicals, offer such resistance when an attempt is made to remove them that a cold chisel and hammer have to be resorted to. This usually renders the drum worthless for further use, and if the contents are not used immediately, they must be transferred to another container.

This trouble can be obviated by a simple method which can be applied with the ordinary tools around a plant. When the usual methods fail to remove the plug, if a slot is sawed through the center of it with an ordinary hack saw and several sharp blows struck at right angles to the slot with a hammer, and a large pipe wrench applied, the plug will come out easily. The slot allows the plug to yield sufficiently to loosen the threads and does not spoil the plug for use.

M. EDWARD BOYD.

Washington, D. C.

## Honorary Doctorates at the Chemists' Club

*To the Editor of Chemical & Metallurgical Engineering*

SIR:—William, he of the dusky countenance and ample girth who erstwhile greeted the members of the Chemists' Club as they entered its portals, has passed away. For a year or more there had been trouble, sometimes with his health, sometimes with his disposition, and as a sequence of the latter irregularity there followed occasional measures of reproof from the house committee. But these are all at an end now and it is our pious hope that clad in golden slippers his airy steps are guided along the jasper streets by Old Black Joe, Uncle Ned, the lovely Nellie Gray and Aunt Dirah of the Quilting Party from the Old Kentucky Home. Perhaps he may even find an abundance of those Kentucky spirits which in life he loved too well and which we shall soon seek in vain.

His memory will always be distinguished because it was he who founded, originated and impersonated the only institution that conferred an honorary doctorate upon every member of the Club. Some of these were merely confirmatory of academic honors already achieved either at home or abroad, and as such they call for no comment. Others again were wholly original and preceded the titles which are anticipated every June, *honoris causa*, by a vast number of the chemists of America. William was the pioneer in these endowments of the mind. To him, every person elected became a Doctor as soon as he qualified in his membership. These titles were known as William's College Degrees.

E. H.

New York City.



## Western Chemical and Metallurgical Field

### Smelting in British Columbia

The dormant investigation of British Columbian smelter schedules authorized by the Dominion Government but halted by lack of funds, will probably be revived by lead-ore shippers following the increase of 45 cents per ton under Schedule B announced recently by the Trail Smelter. S. G. Blaylock, the assistant general manager of the smelting company, in a letter to producers, cites the following increases in smelting expense causing the increase:

Cost of coke increased 40 cents per ton at ovens, equalling an increase of 10 cents per ton on ore.

Wages increased 30 cents per shift, equalling an increase of 45 cents per ton on ore.

Increases in freights on both coke and bullion also went into effect at about the same time, so that in addition to the above increase, all settlements will be reduced by the actual increase in transportation cost.

The Grand Forks smelter of the Granby Consolidated Co., has been shut down. Its closure has been foreshadowed for a year or more by the rapidly increasing costs of mining and smelting and the decreasing tenure of ore received from the Phoenix mines, its main source of supply. Operations at Grand Forks have therefore gradually been curtailed. The recent increase in the price of copper was absorbed immediately by increased freight and labor costs. Consequently the main operations of the Granby Company have shifted to the coast, where the Anyox smelter, handling ore from the Hidden Creek mine, is producing a large amount of copper at a much lower cost.

The Ladysmith smelter has recently indulged in another short campaign, but rapidly exhausted the accumulation of ore on hand. Operations of this sort are today somewhat of an anachronism, reminiscent of the times when blast-furnace operations were controlled by the fracture of slag and matte buttons.

Meanwhile, the Provincial Government has taken an active interest in the exploitation of their large resources in iron ore. Alfred Stansfield has spent the summer investigating the possibility of smelting these ores in the electric furnace, and his report is awaited with much interest by the entire Pacific Coast. Without anticipating his findings, it may be stated that electric pig iron probably could be financed by Californians if gray iron could be produced, lower in silicon and higher in graphitic carbon than the usual electric pig. The latter is not acceptable to the foundrymen in that region, although it is excellent material for steel furnace. Electric steel in competition with open-hearth products merchant and structural shapes would require energy at a cost per kilowatt-hour but a fraction of any present quotation in that region.

**Porphyry Coppers Summary.**—A tabular representation of the performance of the various mills at Utah Copper, Chino, Ray and Nevada Consolidated for the year 1917 is given herewith, together with a comparison of the results for the preceding year. The costs in every case show large increases. Except in the case of Nevada Consolidated they seem to be figured on the same basis and allow for smelter deductions, are

credited with precious metal values and miscellaneous income, are charged with all overhead charges, transportation, refining and selling costs, 5 per cent for depreciation, and a large reserve estimated to cover Federal and other taxes to become due in the immediate future.

The low recovery of the mills of the Utah Copper Co. is said to be due to the use of a lower grade ore than usual, interference by reconstruction in the plants themselves, and to the crowding through of a maximum tonnage (they are running 60 per cent over their normal economic capacity). The revision of the fine-crushing department at the Magna Plant continues slowly. Much work was done at the Arthur Plant. The fine-grinding department was reconstructed and new facilities installed for handling concentrates and tailings. The construction of a new tailings dam covering a largely increased area below the mills and necessitating the revision of several miles of main line railway track was rapidly pushed. The leaching plant was completed, and was being started up at the end of the year. A new coarse-crushing department was designed in order to eliminate delays in handling frozen cars in winter, consisting of a car tippie and a very large crusher, together with the necessary auxiliaries.

At Hurley, New Mexico, additions to the concentration machinery in the original five sections of the Chino mill were completed about the middle of the year, and with the second unit of the crushing plant in operation at Santa Rita an additional tonnage of 11 per cent was immediately treated. The construction of Section 6 was nearly completed, and a flow sheet for Section 7 (to handle 500 tons of oxidized ores in addition to a large amount of sulphides) was worked out from the operation of the 100-ton experimental plant. The good results to be expected from the oxide mill caused the abandonment of further construction of the tailings retreatment plant.

At the Ray concentrator at Hayden, Arizona, an increased copper recovery of 18 per cent was effected on but a 7 per cent increase in ore treated. This result was effected by methods worked out largely by the local

STATISTICS OF JACKLING PROPERTIES

|                                            | Utah Copper<br>Magna | Utah Copper<br>Arthur | Chino      | Ray        | Nevada<br>Consolidated |
|--------------------------------------------|----------------------|-----------------------|------------|------------|------------------------|
| Ore milled, tons.....                      | 7,077,200            | 5,464,800             | 3,608,100  | 3,560,900  | 4,064,095              |
| Change, per cent.....                      | +15.2                | +12.7                 | +16.9      | +7.2       | +2.8                   |
| Copper content, per cent.....              | 1.377                | 1.64                  | 1.635      | 1.462      | 1.462                  |
| Change, per cent.....                      | -0.098               | -0.19                 | +0.028     | -0.170     | -0.170                 |
| Recovery, per cent.....                    | 61.1                 | 69.32                 | 74.53      | 73.08      | 73.08                  |
| Change, per cent.....                      | -1.24                | +2.73                 | +2.33      | -0.79      | -0.79                  |
| Milling costs, cents per ton.....          | 62.28                | 78.40                 | 103.0      | 82.86      | 74.8                   |
| Change, per cent.....                      | +26.93               | +37.46                | +39.0      | +27.51     | +18.9                  |
| Pounds copper in concentrates.....         | 204,855,118          | 81,925,809            | 92,207,356 | 86,834,271 | 86,834,271             |
| Change, per cent.....                      | +4.1                 | +8.44                 | +18.0      | .....      | -11.2                  |
| Average grade, concentrates, per cent..... | 16.615               | 15.47                 | 18.935     | 7.673      | 7.673                  |
| Change, per cent.....                      | -2.099               | +0.65                 | -0.979     | .....      | .....                  |
| Copper in smelting ore.....                | 1,319,324            | 1,413,973             | 5,409,770  | .....      | .....                  |
| Costs, cents per pound.....                | 10.952               | 11.39                 | 12.141     | 10.84      | 10.84                  |
| Change, per cent.....                      | +4.034               | +2.69                 | +2.007     | +2.71      | +2.71                  |

staff, increasing the efficiency of all departments of the plant. During the year a new system of slimes treatment was developed and installed to give final recoveries on 75 per cent of the total tonnage. The recovery of sulphide copper in Ray ores amounts to 83.32 per cent, but only 33.48 per cent of the contents in oxide- and carbonate-copper is saved.

Three-quarters of a million dollars in new construction was expended at the plants of the Nevada Consolidated, mainly for a new crushing plant at the mill, and a plant for pulverizing coal to replace oil as a fuel in the reverberatory furnaces. The coarse-crushing division of the mill now delivers the entire mill tonnage at about 1-inch size, this relieving the fine-crushing departments of their overload. Tube mills have also been installed in the regrinding sections. The recovery of copper from company ores shows a sharp decrease; but as a matter of fact the copper produced in concentrates by the mill was about the same as before, the balance being made up from ores treated on a custom basis.

#### Ore-Dressing Activities of the Bureau of Mines

THE Salt Lake station of the Bureau of Mines is about to occupy a substantial office and laboratory building, erected at a cost of about \$35,000, at a spot alongside the present ore-dressing laboratory. The new building was made possible largely by the coöperation of several mining companies in Utah, who donated perhaps half of the funds for its erection. Besides offices for the superintendent, metallurgist, chemist, and their clerical help, it will contain the laboratories for chemical and microscopic analysis, together with a large library. The University of Utah benefits from the erection of the building by having office quarters for the head of the metallurgical department, as well as a large lecture room at the north end of the building. Thomas Varley has been transferred from the Seattle station to become acting superintendent of the Salt Lake station, where it is possible that the ore-dressing work of the Bureau will become centralized. The present milling equipment, which is unusually complete, suffers in that it requires a considerable tonnage of ore upon which to operate. Consequently the apparatus is being rearranged and remodeled so that lots of a few hundred pounds can be efficiently studied. Mr. Varley has been succeeded in Seattle by Mr. F. F. OVITZ, Fuel Engineer. Work at that point will consist largely of fuel investigations under the direction of the superintendent, and electro-metallurgical work directed by Mr. F. C. RYAN.

#### New Explosives Plant for California

The erection of a TNT plant at Giant, Cal., has been authorized. The estimated cost is \$1,438,000. This plant is to be located on land adjacent to the nitric acid plant of the Giant Powder Company, located at Giant, Cal. The land belongs to the powder company and is to be leased to the Government with option on the part of the Government to renew in yearly periods. The government is to remove the plant whenever it feels that the plant's further maintenance is unnecessary. The contractor will be Grant Smith and Company, of Seattle, Washington. The construction work is to be under the supervision of the Construction Division of the Army. The finished plant will be operated by the Giant Powder Company.

Ninety-day contracts can now be made by manufacturers of sulphuric, nitric and muriatic acids through 1919, giving the government preferential rights if needed for its war requirements at the schedule prices.

## Stringent Regulations on Platinum

WHILE no reliable data has ever been available on platinum production, because much of the Russian output has intentionally not been reported in order to avoid taxes, Prof. J. L. Howe has recently estimated the limits of production in the world up to January 1917 in troy ounces as:

|                     | Minimum   | Maximum    |
|---------------------|-----------|------------|
| Russia .....        | 7,115,482 | 10,128,308 |
| Colombia .....      | 700,000   | 735,000    |
| Borneo .....        | 175,000   | 200,000    |
| United States ..... | 10,000    | 12,000     |
| Canada .....        | 9,000     | 10,000     |
| Miscellaneous ..... | 9,000     | 12,000     |
|                     | 8,018,482 | 11,095,308 |

About 10 per cent of the above is undoubtedly in the United States, but how it is distributed and utilized is not known. Since the catalytic process plants for manufacturing sulphuric and nitric acids are being installed on such a large scale, it is estimated that about 12 per cent of our million ounces of platinum will be used in the 3,000,000-ton catalytic vitriol output. One ounce of platinum is needed for the production of twenty-five tons of catalytic sulphuric acid or forty tons of nitric acid from ammonium per annum.

Now that the Russian supplies are shut off, it has become important that our scattered domestic stocks be inventoried, so that if the need should arise, requisitions can be taken efficiently and with the least hazard to scientific development. Mr. C. H. Conner, chief of the platinum section of the War Industries Board, wishes it known that it is desired to disturb the trade as little as possible but that the co-operation of all citizens in the enforcement of the platinum regulations is essential:

#### REGULATIONS.

The following regulations are hereby promulgated under the provisions of the act of October 6, 1917 (40 Stat., 385), as amended by the act of July 1, 1918 (Public, No. 181), authorizing the Director of the Bureau of Mines, under rules and regulations approved by the Secretary of the Interior, to limit, during the period of the war, the sale, possession, and use of platinum, iridium, and palladium, and compounds thereof:

SECTION I. The War Industries Board is hereby designated under section 21 of the act of October 6, 1917, and the President's proclamation of October 26, 1917, as the agent of the Director of the Bureau of Mines in the execution of the regulations as hereinafter indicated.

SEC. 11. From and after the date of these regulations, under the penalties prescribed by section 19 of the act of October 6, 1917, no person<sup>1</sup> shall:

PAR. a. Use any platinum or platinum scrap, iridium, or iridium scrap, palladium or palladium scrap, and/or compounds thereof, in the manufacture, alteration, or repair of any ornament or article of jewelry.

PAR. b. Manufacture for use in dentistry any metal, metal parts, or alloys containing more than 20 per cent by weight of platinum or 40 per cent by weight of platinum, iridium, and/or palladium combined, or manufacture supplies therefrom.

SEC. 111. From and after the date of these regulations, under the penalties prescribed by section 19 of the act of October 6, 1917, no person shall without a license—

<sup>1</sup>Section 19 of the act of Oct. 6, 1917, is as follows: "That any person violating any of the provisions of this act, or any rules or regulations made thereunder, shall be guilty of misdemeanor, and shall be punished by a fine of not more than \$5,000, or by imprisonment not more than one year, or by both such fine and imprisonment."

<sup>2</sup>The word "person," for the purposes of these regulations, shall be construed in accordance with the definition contained in section 4 of the act of Oct. 6, 1917, which is as follows:

"That the word 'person' when used herein shall include States, Territories, the District of Columbia, Alaska, and other dependencies of the United States, and municipal subdivisions thereof, individual citizens, firms, associations, societies, and corporations of the United States and of other countries at peace with the United States."



PAR. a. Purchase, sell, barter, or deal in unmanufactured platinum, iridium, or palladium, or compounds thereof (including crude, scrap, filings, polishings, or sweeps), except that sales may be made without a license to an authorized agent of the United States or to a licensee authorized to purchase the same; or possess for more than 90 days after the date of these regulations one ounce troy, or more, of such unmanufactured platinum, iridium, palladium, or compounds thereof.

PAR. b. Possess, use, sell, purchase, or barter, for purposes connected with his business, platinum, iridium, palladium, or compounds thereof (except that sales may be made without license to an authorized agent of the United States, or to licensee authorized to purchase the same), if such person be engaged in—

No. 1. Producing platinum, iridium, or palladium, or compounds thereof, by mining.

No. 2. Producing sulphuric acid, nitric acid, or other chemical products where platinum, iridium, palladium, or compounds thereof are used in such production.

No. 3. Importing or exporting platinum, iridium, or palladium, or compounds thereof.

No. 4. Producing platinum, iridium, or palladium, or compounds thereof, either as a primary product or as a by-product of smelting or refining.

No. 5. Manufacturing electrical appliances and/or parts thereof containing platinum, iridium, or palladium, or compounds thereof.

No. 6. Manufacturing surgical appliances and X-ray apparatus containing platinum, iridium, or palladium, or compounds thereof.

No. 7. Manufacturing chemical apparatus and reagents of all kinds containing platinum, iridium, or palladium, or compounds thereof.

No. 8. Conducting or operating chemical laboratories in which platinum, iridium, or palladium, or compounds thereof, are used.

No. 9. Manufacturing scientific instruments containing platinum, iridium, or palladium, or compounds thereof.

No. 10. Manufacturing and/or distributing dental supplies containing platinum, iridium, or palladium, or compounds thereof.

No. 11. Manufacturing and/or dealing in jewelry containing platinum, iridium, or palladium or compounds thereof.

No. 12. Manufacturing or producing any article or product not mentioned above where such business requires more than one ounce troy per month of platinum, iridium, or palladium or compounds thereof.

SEC. IV. Applications for licenses shall be made under oath to any licensing agent duly authorized under the act of October 6, 1917, as provided in the regulations issued under this act.

SEC. V. Every applicant for license will be required to submit with his application a sworn inventory of all platinum, iridium or palladium or compounds thereof in his possession or control; and every licensee will be required to submit at such times as may be designated by the War Industries Board a sworn inventory of his holdings of platinum, iridium, or palladium or compounds thereof in whatever form they may be.

The Director of the Bureau of Mines, at the request of the War Industries Board, may at any time require from any user or possessor a detailed sworn inventory of any and all materials held by him containing platinum, iridium, palladium or compounds thereof, and such inventory must be furnished promptly upon receipt of such requirement.

SEC. VI. All licenses shall be issued in the name of the Director of the Bureau of Mines and countersigned and delivered by the War Industries Board, and shall be, and remain subject to the following conditions:

PAR. a. Each license shall contain such appropriate conditions as the Bureau of Mines, through the War Industries Board, may impose.

PAR. b. The Bureau of Mines through the War Industries Board may change the conditions of the license from time to time, as it may deem necessary.

PAR. c. Records shall be kept by each licensee of all his sales, purchases and other transfers of platinum, iridium or palladium or compounds thereof, and of articles containing platinum, iridium, or palladium or compounds thereof, with the names and addresses of the purchasers, sellers, and/or transferees, and the quantities involved, which records shall be open at all times to the duly authorized representative of the Director of the Bureau of Mines.

PAR. d. Any and all platinum, iridium, or palladium, or compounds thereof, acquired under the authority of such license shall be used strictly for the purposes and in the manner stated in such license.

PAR. e. Upon request of the War Industries Board, the licensee shall report the prices at which sales of his products containing platinum, iridium, or palladium, or compounds thereof, are being made; and the right to prohibit further sale of such articles at prices deemed exorbitant by it is reserved to the War Industries Board.

SEC. VII. Any licenses issued hereunder may be revoked for violation of any of these regulations, or for violation of any of the conditions contained in such license, or if such revocation is deemed necessary or advisable for purposes of the national security and common defense.

SEC. VIII. The War Industries Board will, upon request, furnish a list of Government agents or licensees authorized to purchase platinum, iridium, or palladium, or compounds thereof. Neither the United States nor its representatives will assume any responsibility, financial or otherwise, where sales are made to licensees.

SEC. IX. The prices at which platinum, iridium, or palladium will be purchased by a duly authorized agent of the United States or by such licensee as may be authorized to purchase or sell platinum, iridium, or palladium, or compounds thereof, will be such prices as may be determined by the proper governmental agency authorized to determine such prices.

SEC. X. Whenever such Government agents and such licensees as may be authorized to purchase platinum, iridium, or palladium or compounds thereof, shall refuse to purchase the same from any person who is compelled by these regulations to sell the same, or is forbidden by these regulations to possess or use the same, then such person shall promptly notify the Platinum Section, War Industries Board, Washington, D. C.

SEC. XI. These regulations shall not operate to relieve any person upon whom an order requisitioning platinum, iridium, or palladium or compounds thereof may have been or may hereafter be served, from any obligation imposed upon him by such order.

SEC. XII. These regulations are supplemental and amendatory to the regulations heretofore issued under the Explosives Act of October 6, 1917.

VAN. H. MANNING,  
Director of Bureau of Mines.

Approved, August 17, 1918.

FRANKLIN K. LANE,  
Secretary of the Interior.

## Use of Perchloric Acid as a Substitute for Platinum in Potash Analysis

Precipitate the sulphates present with barium chloride (slight excess) in strong HCl solution, boil and filter off the barium sulphate, if present. Evaporate to dryness and heat until all ammonium salts are driven off—below, red heat so as not to volatilize any KCl. Dissolve in 20 cc. hot water and add a quantity of HClO<sub>4</sub> sufficient to combine with all bases present. Evaporate without stirring, cool, and dissolve residue in hot water. Add HClO<sub>4</sub>, and again evaporate until the heavy white fumes of perchloric acid are given off. Be sure to cool. Take up with 25 cc. 96-97% alcohol containing 0.2% by weight of HClO<sub>4</sub> (1 cc. 60% acid per 300 cc. 97-98% alcohol), breaking up residue with stirring rod. Decant through a weighed Gooch crucible containing a mat which has been washed with the above wash alcohol. Wash once again with the wash alcohol, decant, and transfer the filtrate to the crucible. Wash several times with wash alcohol, dry for an hour at 120-130° C., cool and weigh. The residue is KClO<sub>4</sub>. Dissolve this off with hot water and the crucible is ready for another determination. The accuracy should average between one-half and one-tenth of one per cent.



# Fall Meeting of the American Electrochemical Society

The Principal Feature of the Meeting Was a Symposium on Electrochemical Industries After the War, in Which Specialists Discussed Various Post-War Problems—Meetings for 1919 Will Be Held in New York City and Chicago

THE annual fall meeting of the American Electrochemical Society had originally been planned for Princeton, Sept. 30 to Oct. 2, but owing to the commandeering of the University of Princeton by the Government, the meeting place was changed to Atlantic City. An unusually attractive technical program and the very favorable weather brought the unexpected total attendance to 115. The seriousness of the times was reflected in the program; there were no social functions whatsoever and the main feature was the all-day symposium on "Electrochemistry After the War." The

The occluded element, hydrogen or oxygen, is less closely combined with the solvent metal than is the solute in a solid solution. The form of hydrogen that causes the platinum wire to expand is very likely different from the form that produces the commonly observed increase of resistance during occlusion, but is possibly identical with the hydrogen that causes a diminution of the resistivity of the metal.

In the discussion of Professor Smith's paper, Dr. J. W. RICHARDS referred to the decrease in resistivity of alloys treated in hydrogen, in particular ferrocerium.



AMERICAN ELECTROCHEMICAL SOCIETY AT ATLANTIC CITY, SEPTEMBER 30, 1918

meeting was opened by President F. J. Tone in the Belvedere room of the Hotel Traymore.

The first paper on the program was presented by Professor DONALD P. SMITH of Princeton University on

## PROCESSES WITHIN THE ELECTRODE WHICH ACCOMPANY THE DISCHARGE OF HYDROGEN AND OXYGEN

The effect of the occlusion of hydrogen and oxygen by various metals was investigated. Small wires of palladium, platinum, tantalum and iron were used as anodes and cathodes and changes in electrical resistance and length of wire due to the occlusion of gases were determined. It is well known that when palladium occludes hydrogen, either electrolytically or from exposure to the gas, a marked increase in the electrical resistance of the metal results. Smith found, however, that when a fine platinum wire was made cathode at a current density of about 0.3 amperes per square decimeter, the ohmic resistance of the platinum wire decreased during occlusion of hydrogen until it reached a steady value. Similar results were obtained with oxygen in the case of palladium wires. In general it may be said that both hydrogen and oxygen first enter an electrode in a transitional condition in which they possess a conductance of their own. It appears that this conducting form of hydrogen is not intimately united to the solvent metal, but exists in a state which resembles rather one of mere mechanical enclosure, and this view is supported by the fact that the wires stretch during occlusion. Upon removal of the occluded gas the wires assume their original length and resistivity.

Mr. W. R. MOTT of the National Carbon Company, pointed out that it had always been difficult to place hydrogen in the periodic system and that perhaps the monatomic modification would fit in well in the metal group. In answer to a query by Major FRARY, Professor Smith pointed out that the elongation of the platinum and palladium wires during occlusion does not exceed the elastic limit.

## THE SIGN OF THE POTENTIAL

Professor O. P. WATTS of Wisconsin University next presented a paper on the Sign of the Potential. This question has been the source of long discussions at previous meetings of the Society and the present paper is what might be called the "minority report." Professor Watts argues in favor of the plus sign for the potential of zinc. His strongest argument is that according to present conceptions, the electric current is a flow of negative electrons and these electrons can flow only to material of relatively higher or more positive potential. Messrs. FRARY, FITZGERALD, MOTT, FINK and RICHARDS discussed the paper. The majority favored the adoption of the minus sign by the Society and to have all papers published in the Transactions adhere to the adopted standard.

## SEPARATION OF RADIUM EMANATION AND ITS DETERMINATION ELECTROSCOPICALLY

Mr. J. E. UNDERWOOD of the Bureau of Mines, Golden, Colorado and Professor HERMAN SCHLUNDT of the University of Missouri described an apparatus and method for determining radium in various ores and concen-

trates. The apparatus has proved very serviceable for determining the radium content of monazite sand and the concentrates obtained therefrom in the extraction of mesothorium from this ore.

#### THE EFFECT OF RADIUM EMANATION ON THE HYDROGEN-OXYGEN EQUILIBRIUM

Dr. S. C. LIND, radio chemist of the Bureau of Mines, reported upon an experimental investigation on the Heterogeneous Equilibrium of Hydrogen and Oxygen Mixed with Radium Emanation. Dr. Lind found "that an electrolytic mixture of hydrogen and oxygen gases, when mixed with radium emanation in a spherical bulb of 2 cm. diameter, will combine at ordinary temperature to an extent of nearly 99 per cent of completion, before equilibrium is reached. Through comparison of the known relative efficiencies of alpha rays in bringing about (1) the combination of hydrogen and oxygen, and (2) the decomposition of water, equilibrium would be expected at about 50 per cent of complete combination, if the  $H_2O$  vapor were condensed evenly over the whole inner surface of the reaction bulb. Localized condensation of water will not affect its rate of decomposition until the depth of the layer exceeds the range of the alpha ray in water. This takes place when its area is about 1/35 of the total area. Further localization results in diminishing the opportunity for the decomposition of water and a consequent shifting of the equilibrium toward recombination. The limit would be reached with all the water condensed in a single semi-spherical drop. The equilibrium is then calculated to be 95.5 per cent of total combination. When the quantity of water in the system is large, very high gaseous pressures would be produced before equilibrium results. A theory is advanced that the high pressure produced when an imperfectly dried radium chloride, or bromide, is sealed in a small tube, is due to hydrogen alone, not to a mixture of hydrogen and oxygen, the oxygen having been bound chemically as a basic salt."

#### MILITARY APPLICATIONS OF ELECTROPLATING

Dr. WILLIAM BLUM of the Bureau of Standards gave a very interesting outline of the Bureau's suggested Classification of Protective Coatings on Metal Parts of Military Supplies. For steel or brass which requires protection only during storage and transportation a protective coating of grease, slushing oil or similar compound is to be used; for steel or brass for indoor use or for mild exposure, any protective coating that will produce the desired color appearance and resistance to abrasion. This coating may be applied electrolytically, as for example nickel-plate, or chemically as by the copper nitrate process; or mechanically, as, for example, enamel. For steel subject to moderate outdoor exposure, zinc plating should be given preference. For steel exposed to severe outdoor conditions zinc coatings only should be employed. For steel requiring special protection against corrosive liquids, for example, gas shells, lead plating is to be used. For metal to be used in contact with food, nickel or silver plating, tinning or silicate enamels are prescribed.

#### IRON THAT CAN BE WHITTLED WITH A JACK KNIFE

Mr. F. C. KELLEY of the General Electric Company annealed samples of American ingot iron in an atmos-

phere of hydrogen for three hours at 900 to 950 deg. C. Upon testing the hardness of same he found that it was only 20 points higher than dead-soft copper on the Brinell scale. If annealed copper and annealed iron are each worked to produce a one-third reduction in thickness, the hardness of the copper increases over 100 per cent, while iron increases only about 60 per cent. In the discussion of Mr. Kelley's experiments, COLIN G. FINK pointed out that the hydrogen anneal of the ferronickel core of his leading-in wire was an important step in the process of manufacture of the wire, since the hardness of the core and copper shell must be about the same to insure a constant proportion of copper to core to the very last die in the drawing process.

#### NITRIC ACID BY THE ELECTRIC ARC PROCESSES

Mr. E. KILBURN SCOTT of Manchester, England, gave an interesting exposition of the various arc processes for the fixation of atmospheric nitrogen. He described at length the operation of his own furnace and pointed out the various advantages over other types. The paper was discussed by Messrs. ATWATER and LANDIS. The conical arc flame of the Kilburn Scott furnace is its most characteristic feature. The paper will be reviewed in extended form in a later issue.

#### HIGH-TEMPERATURE RESEARCH

Mr. W. R. MOTT of the National Carbon Company reported upon experiments he had carried out in the carbon arc to determine the Relative Volatilities of Refractory Materials. A vast number of experiments were made and many interesting and important results obtained. We give here a few of the most striking conclusions:

"For materials boiling above iron saturated with carbon (3500° C.), a series of boiling points were estimated on a triple basis of reference (1) to the curves with iron for equal (atomic) amounts of material, (2) fractional distillation and (3) position of deposition at negative crater. The boiling points of this series are as follows:

|                                 | Deg. C. |
|---------------------------------|---------|
| Iron Saturated with Carbon..... | 3500    |
| Silica.....                     | 3500    |
| Palladium.....                  | 3600    |
| Carbon.....                     | 3700    |
| Aluminum oxide.....             | 3700    |
| Chromium carbide.....           | 3800    |
| Vanadium carbide.....           | 3800    |
| Rhodium.....                    | 4000    |
| Platinum.....                   | 4050    |
| Uranium carbide.....            | 4100    |
| Ruthenium.....                  | 4150    |
| Lanthanum oxide.....            | 4200    |
| Titanium carbide.....           | 4300    |
| Yttrium oxide.....              | 4300    |
| Columbium carbide.....          | 4300    |
| Zirconium oxide.....            | 4400    |
| Iridium oxide.....              | 4400    |
| Osmium.....                     | 4450    |
| Molybdenum carbide.....         | 4500    |
| Tungsten carbide.....           | 4600    |
| Thorium carbide.....            | 5100    |
| Tantalum (carbide?).....        | 5500    |
| Tungsten (carbide?).....        | 6000    |

#### DISCHARGE CHARACTERISTICS OF A DRY CELL

Mr. C. A. GILLINGHAM of the National Carbon Company contributed a paper on discharge characteristics of a certain make of dry cell. Tests were made on the well known No. 6 dry cell (2.5 x 6 in.) by discharging to given end-point voltages (1) through constant resistances, (2) at constant current through varying re-



sistances, and (3) through Mazda lamps. The results were illustrated by numerous charts and tables.

#### SOCIETY INVESTS IN LIBERTY BONDS

Following Mr. Gallingham's paper the Directors' meeting was held at which it was unanimously voted to invest \$2000 of the Society's funds in the Fourth Liberty Bonds. This brings the Society's total investment in Liberty Bonds to \$8000. Mr. C. G. Schluederberg, chairman of the Membership Committee, reported 1920 members on the Society's roster. The Board decided to hold the spring meeting at New York City and the 1919 fall meeting at Chicago in conjunction with the Fifth National Exposition of Chemical Industries.

The evening session, Sept. 30, was devoted to moving picture demonstration of the Fixation of Atmospheric Nitrogen at Niagara Falls, Power Development and Electrochemical Industries of the Shawinigan Water & Power Company and the Triplex Steel Process at South Chicago. The pictures were exceptionally clear and brought forth much favorable comment. At the South Chicago plant there will be ten 25-ton electric furnaces, forming the third step in the triplex process. The capacity, upon completion, will be 50,000 tons of triplex steel per month. The cost is about that of present open-hearth steel, according to Professor Richards.

#### SYMPOSIUM ON ELECTROCHEMISTRY AFTER THE WAR

President Tone had arranged for an all-day symposium on Tuesday. This proved a great success; many of the papers were of exceptional merit and the discussions had to be frequently curtailed on account of pressure of time. In his introductory remarks, Mr. Tone referred to the remarkable progress that electrochemistry has experienced within the last few years and emphasized that it was not too early to consider seriously what is to become of the various electrochemical industries after the War.

#### THE FUTURE OF ELECTROLYTIC CHLORINE

Mr. A. H. HOOKER of Niagara Falls reviewed the progress of the chlorine and alkali industry within the last generation and commented at length upon the present world-wide importance of chlorine gas and its numerous compounds: Chlorine for phosgene, for chlorpicrin, for mustard gas, for bleach, chlorine as a cloud gas and for smoke screens, chlorine as a disinfectant and sterilizer, chlorine for chlorbenzol explosives, picric acid and parazol, for chloroform for aeroplane dope and for fire extinguishers. Likewise, England, France, Italy and Japan, to say nothing of Germany, have all materially increased their chlorine output during the War. There will be a large surplus of chlorine after the War at the present rate of production and what is really needed are new uses against which chlorine can be charged at a fair operating price. "Our research departments and universities should give every encouragement to a larger development of our permanent chlorine industry, since the maintenance of these chlorine-producing plants with a constant market is as important to the Government as the maintenance of reserve plants for the manufacture of sulphuric acid, the fixation of nitrogen or any other basic munitions."

#### COMMERCIAL USES OF CHLORINE

Dr. V. R. KOKATNUR, of the Niagara Alkali Company, was the second speaker in the symposium. He enu-

merated and described in detail the present and most probable future commercial uses of chlorine. His paper was very highly appreciated and conceded to be a most valuable compendium. A full publication of Dr. Kokatnur's paper will be made in a later issue. The success of the electrolytic alkali industry depends not so much upon the profits obtained from caustic as upon those from chlorine. Hence chlorine is to be considered the primary product.

#### THE WAR AND THE NITROGEN INDUSTRY

Dr. W. S. LANDIS, of the American Cyanamid Company, presented the after-the-war possibilities of the nitrogen-fixation industries. The commercial production of air nitrates is but ten years old. In 1903 the world's production of nitrogen in the form of Chilean nitrate and of sulphate of ammonia was equivalent to only 503,000 short tons of nitrogen. In 1914, at the outbreak of the European War, the producing rate of the world in short tons of chemical nitrogen was as follows: nitrate of soda, 425,000; sulphate of ammonia, 285,000; arc process products, 11,000; cyanamid products, 31,000; synthetic ammonia and miscellaneous, 12,000; total: 764,000 tons. The estimated total for 1919 is 1,341,000 tons of which cyanamid products contribute 360,000 tons. The total production of nitrogen in the United States alone in 1919 is estimated at 509,000 tons, or 38 per cent of the world's output. The United States producing rate in the early part of 1919 will therefore be approximately three times that at the outbreak of the War. At the close of the War our consumption will probably be less than 50 per cent of the production. To take care of the excess nitrogen products, the fertilizer industry offers the most hopeful field of investigation. The Cyanamid company has appreciated the situation and has developed a new, highly concentrated fertilizer containing some 65 per cent of plant food, compared to 12 per cent and 20 per cent, the former standards. The cost in handling and freight will therefore be greatly reduced and the narrow strip of fertilizer-consuming farms along our coast, will be extended many miles inland. When fertilizer can be profitably put into the Middle West the consumption will be enormous. It would take the stimulating effect of several wars to build sufficient fixation plants to over-produce in such a market.

In the discussion of Dr. Landis' paper, Mr. C. G. ARWATER suggested that hereafter the modified Haber process be referred to as the "General Chemical Company's Synthetic Ammonia Process." The introduction of concentrated fertilizers which could be cheaply transported to our Central and Middle-West farms deserves every bit of encouragement. Mr. E. KILBURN SCOTT estimated the world's total arc processes for nitrogen fixation at 635,000 horsepower, and on the basis of 60 to 80 grams per kilowatt-hour an equivalent of 50,000 tons of arc-process nitrogen for 1919, and not 15,000 as estimated by Dr. Landis.

#### THE ELECTRIC FURNACE AFTER THE WAR

Mr. F. A. J. FITZGERALD, of Niagara Falls, talked on the electric furnace after the War. Some of the electric furnaces will undoubtedly go out of business. But many of the types will survive the strain of the reconstruction period. The induction-type furnace did not



develop as was expected. The advantage of dispensing with electrodes cannot be overlooked. Although the induction furnace is at present contending with lining and design troubles it seems most reasonable to expect that some modification of the Hering furnace will win out eventually. In general, the electric furnace situation after the war will be very largely dependent upon water-power development. Government ownership of water power is the most serious menace to the electric-furnace industry. It seems that the hour is rapidly approaching when it must be decided whether "the people exist for the state, or the state exists for the people."

In the discussion, Mr. ROBERT TURNBULL, of Welland, Ontario, agreed with Mr. Fitzgerald that water powers ought not to be in the hands of the government. Plants can be ordered shut down at any time and there is no redress. Mr. C. H. VOM BAUR, electric furnace engineer, of New York, maintained that as far as the electric steel industry was concerned, the future was well assured. Not only on account of the high quality of the electric steel as compared with ordinary steel, but also as a matter of economy, the electric furnace will survive and prosper. Many plants will introduce the duplex process, others will use the electric furnace for keeping ferromanganese molten and still others will maintain the electric furnace for melting scrap. At  $\frac{1}{2}$  cent per kilowatt-hour it is cheaper to melt scrap in an electric furnace than in any other. Mr. C. G. ATWATER brought up the question of power rates. Mr. P. J. KRUESI, of Chattanooga, Tenn., inquired as to the furnace patent situation after the War and hinted that difficulties might arise. Mr. E. KILBURN SCOTT cited the experience of England in municipal ownership of power plants. The outcome was most unfortunate. The biggest unit in England to-day is 15,000 kw. whereas in the States units of 60,000 kw. were not uncommon. Mr. HENRY E. RANDALL, lately with the Shawinigan Water and Power Company, discussed power rates and mentioned that the consumption of electric power in Ontario was 2.5 times greater per capita than in any other community. By cutting the rates in half the income from power users increased from \$700,000 up to \$840,000, whereas the returns on lighting dropped from \$300,000 down to \$250,000. However, the total income increased by \$90,000.

#### THE FUTURE OF ELECTRIC STEEL

Dr. JOHN A. MATHEWS, President and General Manager of the Holcomb Steel Company, contributed a paper on the Future of Electric Steel. "We are in our thirteenth year in the manufacture of electric steel. In automobile and airplane construction, and in many other ways, electric steel has given a splendid account of itself. Electric steel may well be called 'super steel.' It has had the indirect effect of stimulating better production on the part of open-hearth and Bessemer steel makers, and thus it may be considered as a beneficial acquisition to the entire steel industry. Easily oxidizing metals, like vanadium, chromium and manganese are readily handled in the electric furnace, and hence less of them need be had to use a final minimum content in the steel. Less of the oxides of these metals will be produced in the steel and therefore less of these oxides need be removed. Sulphur and phosphorus can be readily eliminated. With the electric furnace, alloy steels are made in the furnace itself rather than in the ladle, and

in this way there is better opportunity for increasing the solution, diffusion and homogeneity in the product. The field for electric steel in the future is a very promising one and when its merits are fully recognized new additional uses for it will be found."

Dr. MATHEWS' paper was discussed by Messrs. RICHARDS, EMERSON, SCHLUEDERBERG, DARLINGTON, MILLER, SCOTT and TURNBULL. Dr. RICHARDS referred to the manufacture of armor plate. Fifty per cent of the alloy goes back to the furnace and practically all of the chromium is lost on remelting. If electric furnaces could be introduced in the manufacture of armor plate a great saving would be brought about since practically all the chromium would be retained by the alloy. All attempts to convince the authorities of the advantages of the electric method have been of no avail. Electric steel production often requires less skilled labor than does the open-hearth or crucible process. Mr. DWIGHT D. MILLER prophesied that the electric annealing furnace would surely continue to prosper after the War on account of its numerous advantages and economies over older methods: electric annealing is automatic and absolutely reliable. Conditions of temperature and time can be most closely controlled and readily duplicated. For example, in the heat-treatment of anchor chain, all links receives similar treatment. Mr. Miller also believed that electric brass-melting had come to stay, as it is a cheaper and better process. Mr. KILBURN SCOTT mentioned that the electric furnace had been the salvation of the aeroplane industry in England. Furthermore, electric furnace smelting of scrap right outside of London had saved useless freight trips to and from Sheffield.

#### ELECTRIC PIG IRON AFTER THE WAR

Mr. ROBERT TURNBULL, of Welland, Ontario, gave a highly interesting presentation on Electric Pig Iron After the War. This industry is still in its infancy. A year ago the total output of Canada was only 900 tons of electric pig per month. To-day this output in Canada has attained over 2500 tons, and by the latter part of November the production will be between 4000 and 4500 tons per month. The consumption of electrodes is about 21 pounds per gross ton of iron. The power consumption aggregates a little over 500 kw.-hr. per gross ton. The average analysis of 25 consecutive heats is as follows: Si, 1.16 per cent; S, 0.014; P, 0.020; Mn, 0.70; and C, 3.19. The desired silicon is 1.00 to 1.25 per cent. At present this low-phosphorus pig iron is made from scrap shell turnings. After the War this supply of scrap will cease. However, similar scrap will undoubtedly be available, since it is very probable that the open-hearth will discontinue the use of turnings as a matter of economy and expediency as soon as it can obtain its supply in heavy-melting scrap. If, however, the quantity of turnings available is insufficient to meet the demands of the electric pig industry, it is probable that the present furnaces would be used for smelting iron ore. About 1400 kw.-hr. is required to produce one gross ton of pig iron from a mixture of 50 per cent ore and 50 per cent turnings. The quality of electric pig is superior to that of ordinary pig and this in itself will very likely insure a steady demand for electric pig iron by high grade steel manufacturers after the War.

## THE POWER SITUATION AFTER THE WAR

Mr. C. A. WINDER, of the General Electric Company, spoke at length on that most vital of all questions, The Power Situation After the War. We have too long looked upon power production as a simple problem, an economic factor that would gyrate nimbly to the tune of "supply and demand." No definite action has been obtained from Washington simply because no comprehensive demand has been made upon the legislative bodies there. Water turbines have an efficiency of approximately 90 per cent compared with 8 per cent of the reciprocating engine, 17 per cent of the gas and oil engines and 21 per cent of the steam turbine. The super-steam-station idea, locating power plants of a half million horsepower at the coal mines, is as "fantastic and extravagant as a caliph's dream." A half million horsepower plant would require 55,000 cubic feet of water per second or considerably more than the entire Ohio river during its normal period. Water-power is the only economic power and "there is no reason why water power industry should not develop quickly to a size and importance far beyond the fondest dreams of the present day pioneer."

Mr. HENRY E. RANDALL in discussion pointed out that if all the water power in the United States were developed it would not take care of the present day demand. A large consumer of electric power is the storage battery and a battery of about half the weight of the present would find a very big market. The use of peak power is rapidly increasing in Canada and has resulted in a much higher general load factor. Dr. RICHARDS thought that super-steam stations ought not be discouraged on account of the question of cooling water supply. Although the water near mines is acid, acid-proof condensers could be used. Mr. KILBURN SCOTT said that in England it would be considered best practice to locate the super-steam stations at the water-side and to carry the coal in pipe lines to the stations. Mr. SCHLUEDEBERG, of the Westinghouse Company, referred to the large steam plants being built at coal mines in Pennsylvania. Mr. Winder added that if the government would act favorably toward water-power development, private interest would obtain capital for such developments easier.

## SURPLUS ELECTRIC POWER AFTER THE WAR

Dr. JOHN W. BECKMAN, of San Francisco, suggested in his paper two outlets for surplus electric power after the war. "Two industries, both of them basic and both of them producing products essential to mankind, appear as suitable life savers to the electric developments after the War." One of them is the iron and steel industry and the other is the fertilizer industry. A very important electro-metallurgical development awaiting a successful solution is the direct manufacture of steel from iron ore. We have already reached forward toward this goal; in the electric shaft-furnace pig iron is now produced, known as steel pig iron. The next step will be the finished steel. The other industry which would serve to consume power after the War is the fertilizer industry. Two of the important ingredients in a fertilizer are nitrogen and phosphorus. The nitrogen-fixation industry will continue, particularly if encouraged by the Government. It is an industry essential

in times of peace as well as in war. The phosphorus in our phosphate rock, distributed through many of our states, can be made completely water-soluble by electrical methods, whereas by the old sulphuric acid method, only a small per cent of this phosphorus is rendered water-soluble.

Discussing Dr. Beckman's paper, Dr. LANDIS, of the Cyanamid company, was of the belief that eventually there would be an international committee to guide and control the development of industries. The application of fertilizers might well be regulated or ordered by the governments. The same applies to the power developments. Everything points toward a government control of industries. Probably the railroads, telephones and other utilities will never go back to the old system after the War. Mr. L. E. SAUNDERS, of the Norton Company, called attention to the new interconnecting of power plants at Niagara Falls resulting eventually in much lower rates. Mr. ACHESON SMITH, of Niagara Falls, pointed out that the fertilizer industry was of the elastic type. When food prices are high, farmers have large incomes and gladly buy fertilizers; when food prices are low farmers will be forced to buy fertilizers.

THE GOVERNMENT AND THE TECHNICAL MAN  
AFTER THE WAR

Dr. F. A. LIDBURY, in his usual highly entertaining style, submitted his reflections on the government and the technical man after the War. It appears most probable that a number of the scientific boards and committees appointed during the War will continue after peace is signed. Furthermore, the present close working of men of pure science with those who have specialized in applied industry and engineering has proved so vastly beneficial to all parties concerned that "one may feel quite certain in hazarding the conviction that the two fields will never fall so far apart as before, and that industry will be the gainer to the extent that it permanently receives the originality of view and boldness of conception of the pure scientist."

Mr. H. B. COHO, of the United Lead Company, in discussing Dr. Lidbury's paper emphasized that the underlying, fundamental question for us to answer is: "Are we as technical men willing to take on the responsibility of government? Are we ready to shoulder the duties of a governmental office?"

Mr. L. E. SAUNDERS offered the following two resolutions: (1) That the American Electrochemical Society is in full accord with the policies of the United States Shipping Board and will gladly cooperate in every way. (2) That the Public Relations Committee of the Society investigate the pros and cons of government ownership of water power.

## RESEARCH AFTER THE WAR

Colonel BANCROFT received a well deserved ovation as he arose to present his views on research after the War. He heads the Electrochemical Committee of the National Research Council. "Remarkable changes have been brought about by the War. This applies to all branches of chemistry. In organic chemistry the whole situation has been changed; we have learned to consider yields. The application of physical-chemical methods to organic chemistry offers great possibilities.



Some of the poisons recently developed, such as the arsenical and prussic acid compounds, might become valuable insecticides. New organic gases that are now used to kill men might, after the war, be used to kill bugs. For many years after Sabatier's research on catalytic agents very little progress was made along these lines in organic chemistry. During the last few years, however, various catalytic agents have been used for making war gases and other compounds. We are just beginning to realize the vast possibilities. The new charcoal catalyst is better than any we made before. We are bound to find extended uses for it. In the production of ammonia a number of catalysts have been found which will surely be useful after the War. A completely new field of scientific research is bound to open up. How is this research going to be carried out? The National Research Council is encouraging the scheme whereby each industry will have its research laboratory, as for instance that of the American Cannery Association. It will also be important that the universities have research laboratories where the scientific basis of our industries could be investigated."

In the discussion, Dr. LANDIS suggested that handbooks include in the description of processes the yields of the products obtained.

#### COÖPERATIVE RESEARCH LABORATORIES

Dr. C. E. K. MEES, of the Eastman Kodak Company, spoke at length on coöperative research laboratories, their advantages and limitations. He pointed out that Great Britain had already inaugurated the scheme of establishing coöperative research laboratories and that results so far were very encouraging. The English Government subscribes one-half toward the cost and maintenance and the other half is covered by individual subscription from each member of the industry. These laboratories are very often operated in connection with the universities. There are five distinct types of problems that can be covered by a research laboratory: (1) fundamental research. (2) raw materials; new sources; new methods of working up. (3) products. (4) processes. (5) applications. Research of the types 1, 2 and 5 interests all industries. They are external to the works. However, numbers 3 and 4 are internal and are not suitable for coöperative research; they involve secret, competitive methods. The British Government therefore assumed that everybody would be interested in fundamental research when inaugurating the system. At the Rochester laboratory of the Eastman Kodak Company about \$30,000 a year is expended on fundamental research. "In one case we worked for five years before we found out what we were looking for!" But the new by-products found and developed during this time made the pure research a paying thing. There is also a good deal of advertising value in having a "tame research man" go to various society meetings and talk on the laboratory's pure research. As a result of his high-toned talk you will get orders. A research laboratory in a small concern can often make more money than a similar laboratory of a large corporation. In the latter there is too much red tape, whereas the small laboratory can go right ahead and make the new article and sell it to the public. What this country needs are National Research Laboratories, for example a National Alloys Research Laboratory to which all inter-

ested industries would subscribe. There are very few industries not interested in alloys. Similarly, let us have a Fuel Research Laboratory, a Metal-Cutting Research Laboratory—about a dozen national research laboratories of this type.

In discussing Dr. Mees' remarks, Mr. SCHLUEDEBERG suggested that some scheme be advanced for the coördination and coöperation of the various research laboratories now operating in this country. Thus much duplication of effort could be avoided and no doubt better and more rapid progress in research made. Dr. FINK referred to the deplorable condition of our patent laws and said that much of the success of the research laboratories depends upon proper protection and recognition of original products and processes. Dr. R. E. ZIMMERMANN, of the Research Laboratory of the American Sheet and Tin Plate Company, discussed the value and importance of research on the standardization of products. Mr. MOTT pointed out the dire need in this country of handbooks covering the various industries, handbooks such as are found in Germany. Dr. RICHARDS suggested that it would be well worth while studying the history of the Swedish Iron Masters' association in connection with establishing coöperative research laboratories in this country. Dr. M. G. WEBER called attention to the fact that very often new and valuable processes were not made public properly. He favored the appointment of a committee whose duty it would be to bring to the attention of the industries and its members the importance of a new process or product. Mr. C. P. MADSEN commented favorably upon the Patent Approval Association that is now working in conjunction with the National Research Council. Mr. KILBURN SCOTT announced that England was setting up a large research laboratory that was practically a duplicate of the Mellon Institute at Pittsburgh. What is needed in England and in fact in all countries is a committee that would look after the interests of "the poor inventor." In closing the discussion, Dr. MEES conceded that the patent question is a very important one and that some years ago he had written a paper outlining a Utopian Patent System—but being afraid of his lawyer friends, he never published it.

#### TARIFF PROBLEMS IN THE ELECTROCHEMICAL INDUSTRIES

Dr. GRINNELL JONES, chemist of the United States Tariff Commission, presented a paper on the tariff problems in the electrochemical industries. The Tariff Commission is trying to gather information which will be of value after the War. In the chlorine and caustic soda industry protective tariff legislation, 25 years ago, helped the development of the industry. Chemically we get the two products in equivalent amounts, but commercially the demand for caustic exceeds that for chlorine. We have therefore had large imports of bleaching powder. Between 1909 and 1913, 40,000 tons of bleaching powder was imported annually. In 1909, 58,000 tons was produced in the United States and in 1913, 155,000 tons. Our imports of bleaching powder in 1916 dropped to 16,000 tons, in 1917 to 33 tons and in 1918 to 2 tons. Our exports in 1913 will probably total 6500 tons bleaching powder; to this must be added the chlorine in form of poison gases. In 1914 we exported 43,663 tons of electrolytic soda and in 1917, 126,570 tons. What are we going to do with the excess chlorine after



the War? Not much help is to be expected from the dye industry since this consumes only about 2 per cent of the output. The carbon tetrachloride industry consumes but one per cent of the output. Chlorine manufacturers and chlorine consumers must keep the Tariff Commission closely advised as to production, consumption and new outlets.

In the abrasive division of the tariff laws there is at present considerable discrepancy in the duties imposed on the various products and raw materials. Grindstones and hones are on the free list and no distinction made whether composed of natural or artificial abrasives. On the other hand emery stones are taxed. Better classification is needed. The demand for artificial abrasives is greater than the available water power. About two-thirds of the artificial abrasives are now imported from Canada. Shall we put a duty on Canadian abrasives? We are now producing large quantities of phosphorus. And what is to become of the potash industry after the War? As regards the nitrogen-fixation industry, is the Government going to levy a protective duty and protect itself? It is necessary to collect in advance information in order to draw up proper tariff legislation, and the coöperation of the men of the industries is absolutely essential.

Mr. L. E. SAUNDERS, of the Norton Company, did not fully agree with Dr. Jones' statements relative to the abrasive situation and maintained that the shortage of natural abrasives had been fully met by the manufacturers of the artificial products. There is at present even an overproduction of artificial abrasives.

In bringing the symposium to a close, President Tone expressed his and the Society's appreciation for the highly interesting papers contributed and hoped that the serious problems that had been brought before the Society would give rise to further debates and discussions and future meetings.

#### THE NORTHRUP HIGH-FREQUENCY FURNACE

The main part of the Tuesday evening session was devoted to the new Northrup furnace. Dr. E. F. NORTHRUP, of Princeton University, gave a highly interesting address describing in detail the construction, development and operation of his latest type of induction furnace. A preliminary announcement and description of the Northrup furnace appeared in the Aug. 1, 1918, number of this journal. The experiments were started about two years ago for the Ajax Metal Company, of Philadelphia. Mr. G. H. Clamer, vice-president of the company, deserves much credit and appreciation for his support of the enterprise and his broad vision. Dr. Northrup also paid a graceful compliment to his mother who had ever taught him to have high ideals. It was a high ideal that formed the original conception of the new high-frequency induction furnace: "Heat the charge or its container without heating anything else."

The resistance type of furnace could never realize this ideal. The best resistance wire will stand but 1282 deg. C. and a furnace built of this wire would with difficulty melt copper (1082 deg. C.). For example, when the heat of this resistance furnace has reached 1081 deg. there is a temperature gradient inwards of 201 deg. and outwards to the room of 1282 deg. If we were to try to melt an alloy, of melting point 1282 deg., the efficiency of the furnace would be zero. Therefore for

high efficiencies the heat must be generated within the container. The high-frequency induction furnace is the solution of the problem. In order to attain the very high frequencies required, Dr. Northrup developed a high-frequency oscillatory discharge gap: there are three Acheson graphite electrodes surrounded by an atmosphere of alcohol. Eventually with the further development of the Alexanderson high-frequency alternator this discharge gap will be dispensed with. It is planned to build alternators of 1000-kw. capacity, whereas the largest units at present are rated at 200-kw. and 2300 cycles. In the present small type Northrup furnace brass can be melted at the surprising rate of 45 pounds in 35 minutes. Nickel is readily fused. In the small furnace, equipped with the oscillatory discharge gap, the efficiencies are around 50 per cent whereas eventually with an Alexanderson alternator efficiencies of 90 to 93 per cent are more than probable. One of the proposed large-scale adaptations of the new furnace is for the retention of the heat in the steel ladle. In this case the ampere turns would be embedded in the refractory lining of the ladle. In conclusion Dr. Northrup referred briefly to his "focus inductor" furnace in which any temperature that a magnesia crucible will stand can be attained. Messrs. SCOTT, BRALEY, CUMMINS, BRADLEY, ROUSH and MOTT participated in the discussion.

#### THE NORTHRUP FURNACE IN OPERATION

Dr. Northrup's address of Tuesday evening was supplemented by a personal inspection of the furnace at the Pyroelectric Instrument Company's laboratory at Trenton. The members of the Society left the Traymore early Wednesday morning arriving at Trenton about eleven o'clock. Dr. Northrup demonstrated at his laboratory how easily nickel could be melted in the high-frequency furnace and in a second experiment, roller-bearing rings were brought up to the desired quenching temperature in a very few minutes. In the latter case no crucible was required: the energy was focused directly onto the rings. There were also demonstrations of the high-frequency arc and focus inductor. The visit to the Pyroelectric laboratory was one of the most enjoyable features of the meeting. It was generally conceded that the high-frequency furnace was the greatest advance in electric-furnace design since the days of Moissan.

#### Prices of Sulphuric and Nitric Acids

On Oct. 4, the War Industries Board modified the division made on September 26 in evaluating sulphuric acid, whereby 92 per cent  $\text{H}_2\text{SO}_4$  instead of 66 deg. B. (93.19 per cent) shall be the division point. Acid below 92 per cent  $\text{H}_2\text{SO}_4$  shall be evaluated according to its equivalent of 60 deg. B. acid at the price of \$16.00 per ton; and acid above 92 per cent  $\text{H}_2\text{SO}_4$ , on its equivalent of 66 deg. B. at \$25.00 per ton. See CHEMICAL AND METALLURGICAL ENGINEERING, page 571, for first announcement.

On Oct. 3, the statement of 8½c. per lb. as the flat rate for 42 deg. B. nitric acid was further amplified to read 67.18 per cent. This makes the price of nitric acid 2.53c. per ton unit, which is \$170 per ton for 67.18 per cent acid. This price applies to mixed acid also, in which  $\text{H}_2\text{SO}_4$  shall be 0.268c. per ton unit.

## The Use of Micro-organisms in Chemical Industry

**Yeasts, Moulds and Bacteria Important Organic Chemicals Widely Used in Industry — Further Industrial Applications and Developments Await Research — Some of the Possibilities**

BY ERNEST G. GENOUD

**T**HE MICRO-ORGANISMS to which we refer are yeasts, moulds and bacteria. They are of the nature of plants, and, like their vegetable colleagues most of them require for their growth and development carbon, nitrogen, water, oxygen, phosphorus and calcium. Many of them, like other plants and unlike animals, can metabolize nitrogen in the form of simple soluble salts instead of complex proteid substances. Others, again, find their principal nutriment in proteins.

They are classified according to their external forms. In physical appearance but not in any biological sense we may say that yeasts resemble microscopic vines, moulds resemble moss, and bacteria, rods and spheres. Their functions are of almost infinite variety, and there is a vast deal about them that is not known.

In a chemical sense the most familiar of all are the yeasts, or more particularly the saccharomyces, which split fermentable sugars into ethyl alcohol and carbon dioxide. They secrete especially two enzymes of which one goes forth from the yeast cells and effects a transformation of some sugars from an unfermentable into a fermentable organization. This does not consist in splitting them into single carbon chains. Some monosaccharides are not fermentable while some di- and trisaccharides are. The second enzyme remains in the yeast cell, and as the solution of fermentable sugars enters the walls the desired reaction takes place.

### NITROGEN ESSENTIAL TO FERMENTATION BY YEAST

If a culture of yeast is introduced into a solution of pure sugar and pure water, the ensuing fermentation will be very incomplete, for the obvious reason that there is no nutriment present for the yeast, so that its growth and progress are halted. It must have soluble nitrogen salts or compounds, and in the fermentation for beer or alcohol from grain or starch this is found in asparagin and other amido acids which are present in all young sprouts and especially in the barley sprouts of the malt. The primary purpose of the malt, as is well known, is to provide the enzyme diastase to convert the starch to sugar. Certain moulds may take the place of malt in this process. Our readers may recall such a mould introduced by Dr. Takamine from Japan which was a culture, as we recall it, used in the production of sake from rice in that country. In France there is now a great industrial alcohol plant using potatoes for starch, and there a mould instead of barley malt is employed. When sugar is the initial material instead of starch, as in the case of grapes or molasses, no malt or diastatic agent is required in fermentation.

We shall not address ourselves to the main process of fermenting sugar to alcohol and CO<sub>2</sub>, which is familiar to all chemists, but consider rather some of the by-products which are always present, and are found in

varying proportions. These are iso-butyl and amyl alcohol, glycerol, succinic acid, acetaldehyde, acetic acid and various esters. Just how iso-butyl alcohol is formed as a product of yeast fermentation is not known. We shall not consider the subject at length because butyl alcohol is produced in great quantities in one of the biological processes for making acetone, and again butyric acid is obtained direct from starch by a special bacillus, so that if an industrial demand for either the acid or the alcohol should arise it may be met in abundant quantity. Amyl alcohol on the other hand is called for with a loud cry, and fortunately it is known that its presence is due to the fermentation of proteid substances and not to that of sugar. It is sorely needed for the production of amyl acetate as a solvent for nitro-cellulose and, to a less extent, for synthetic fruit syrups and perfumes. And if it ever should become cheap enough, the industrial steps from amyl alcohol to isoprene and from isoprene to synthetic rubber are nearly in sight. There is, therefore, every reason for the incidence of research upon the problem of cheap production in large quantities of this once detested and injurious ingredient of potable liquors. When we get to know beans as well as Dr. Theodore B. Wagner and certain other chemists know corn, and even before that, it may become a profitable enterprise to study the fermentation of proteins to fusel oil along with the starch to ethyl alcohol. Since beets are grown with profit in the beet sugar industry it may be that beans will be grown with profit to produce ethyl alcohol together with large quantities of amyl alcohol. The subject is full of interest. In present day fermentation it sometimes happens that iso-butyl and amyl alcohols are found to the extent of 3 to 1 per cent in crude distilled spirits.

### GLYCEROL PRODUCED IN SMALL QUANTITIES

Glycerol seldom runs above one-third of one per cent of the fermented mash, and it has not been found economical to separate it thus far, notwithstanding the war's demands for glycerine for nitrating purposes. How it is produced is not known; that is, there is less known of it than there is of the production of amyl alcohol by fermentation. Whether under post-war conditions there will be any such demand for glycerine as there is at present is open to question. Whether also the road to biologically produced glycerine is too long to be undertaken in the face of the immediate demand is also a subject for discussion. Perhaps the matter is already in hand at American University. According to reports lately received the Germans have developed a yeast of which the cells contain as much as 40 per cent of fat in the dry substance instead of about 5 per cent which is the usual proportion. It is said that they have been cultivating this in quantity and removing the glycerine by saponification, but we do not guarantee the truth of this statement.

The more specific production of succinic acid and the innumerable esters are also subjects for research in less crowded hours, while the steps from ethyl alcohol to acetic acid are known and studied, and are in good hands.

At the present stage of the art it may be said that the development of excessive undesired by-products in the fermentation for ethyl alcohol is usually due to

infected yeast and occasionally to overmuch foaming of the beer and the consequent oxidation that ensues.

#### CONSTRUCTIVE AND DESTRUCTIVE METABOLISM OF YEAST

In the production of alcohol, whether for drink or industrial uses there is always a great excess of yeast grown, because of the rapidity with which the cells reproduce. Under favorable environment the plant thrives lustily and while the manufacturer is always careful of the comparatively small amount that goes into every fresh vat, he has a great quantity left over after every fermentation.

Here is waste, a serious waste, and one that should be avoided. Usually it is messy stuff and like most good things that we discard, it does not behave very well under such treatment. Being rich in protein it is a valuable food. Properly treated it is good cattle fodder, and still more carefully treated it is excellent human food, and is considerably used in England for this purpose. The preparation is interesting: In the building up of yeast cells, as we have already observed the nitrogenous constituents may begin with very simple ammonium salts. In the metabolism of the plant these ascend in steps of increasing complexity to amido acids, peptones and albumoses to insoluble albumen. Now, if the yeast is washed free of all wort and mash and is left to stand wet or in pure water, it proceeds, having no nutriment, to consume itself by a process of auto-digestion, induced by the enzyme endo-tryptase. At the optimum temperature of about 40 deg. C. the insoluble albumen is broken up and the direct reverse of the metabolic process takes place. There occurs a breaking down, in consecutive order, of insoluble albumen to albumoses, peptones, amido acids and, finally, ammonia.

#### VEGETARIAN "BEEF EXTRACT"

This is not putrefaction, and unless the yeast is infected putrefaction will not take place. By halting the process at a point at which the peptones and amido acids predominate, and sterilizing at about 70 deg. C. to destroy the enzymes, the product remains stable. For convenience of transportation and use it is then concentrated and the result is a food which is fully equal to beef extract, containing up to 35 per cent of peptones and amido acids. If properly made it is very agreeable to the taste and is not to be distinguished from beef extract save by very astute analysis. It has reached an important industrial stage in England and the yeast product made in this manner is sold as vegetable extract under the trade name of Vegex. It enables the vegetarian to have his beef juice without the passing of the steer, but its consumption is by no means limited to vegetarians. The amido acids are excellent digestive stimulants.

For cattle feed the yeast is washed and dried. Being relatively rich in nitrogen, potash and phosphorus, it should also serve well as a fertilizer.

#### BACILLI PRODUCE ORGANIC ACIDS

The most widely known industrial use of moulds is in the production of cheese, to which we shall give but passing mention and proceed to consider bacteria which are divided into three classes, according to their external form. They are of almost endless variety.

They are the smallest forms of plant life, some being not over  $2\mu$  in length. The spirillum, on the other hand, which is also a variety of bacteria, grows up to the length of 12 to  $15\mu$ . The three principal types are the bacilli which are rods somewhat of the shape of minute Frankfurter sausages, the cocci which are spherical, and the spirilla which are corkscrew shaped.

The lactic acid bacillus has the function of converting almost any starch into sugar and the sugar into lactic acid, and it is impossible to isolate the sugars during the process. It is used by manufacturers of compressed yeast, who look for the greatest production of yeast rather than of alcohol, because it decomposes the complex albumen molecule and brings it down to amido acids, at which point the yeast is much more able to assimilate its nitrogen. If the demand for lactic acid should increase there should be no difficulty in meeting it.

There is also a butyric acid bacillus which attacks starch, sugar and lactic acid and produces the ill-smelling butyric acid. And in recent years bacteria have been discovered which produce acetone from carbohydrates, along with a greater quantity of butyl alcohol as a by-product.

The cocci and spirilla are more generally known from their pathogenic representatives, although there is no known rule or relation between the shape and size of a micro-organism and its function.

#### SOME FUTURE PROBLEMS

We have considered a few of the bodies known to be produced and it seems as though properly directed research might not only add to the sum of knowledge but enhance the national estate as well. Let us therefore engage the imagination a little and see what possibilities beckon us over the fire-fly swamps where the roads have not been laid out as yet. If we have yeast to make ethyl alcohol in quantity from sugar and starch and amyl alcohol inadequately from proteid substances, and a bacillus for butyl alcohol from starch, why should we not find or develop a culture for propyl alcohol, and more especially for the production of methyl alcohol? We separate cetyl alcohol,  $C_{18}H_{37}OH$ , from spermaceti, and melissyl alcohol,  $C_{26}H_{53}OH$ , from beeswax. The higher alcohols are excellent waxes; why not try to find a micro-organism to make them in tubs? These are likely to be cheap processes if they are started right.

Again there is the fermentation of cellulose to methane and hydrogen. Here is an enormous field for study. Nature does it in marshes and in the earth, so why should we not wring the secret from her and get it under control? Even the gases formed within the body are due to the fermentation of cellulose and not to that of starch or proteins. Under proper conditions we could grow our own gas, making it fresh every day, and save coal. Imagine a great vat in a prosperous village, seething away, fermenting wood-waste, garbage, old newspapers, and rubbish of every sort, and delivering methane and hydrogen into a convenient gasometer. Observation thus far seems to indicate that the cellulose is hydrolyzed to sugar by means of an enzyme and that fermentation proceeds to  $CH_4$  and  $H_2$ , while the lower fatty acids arise as by-products.

Arthur D. Little, Inc.,  
Cambridge, Mass.



# Reinforced Concrete versus Salt, Brine and Sea-Water\*

An Account Citing Many Examples of Failures in Reinforced Concrete and Showing the Cause to Be Due to Electrolytic Corrosion of Reinforcements

By HENRY JERMAIN MAUDE CREIGHTON

ON ACCOUNT of the rapidity and cheapness of construction, at present attention is focused on the reinforced concrete ship. A large reinforced concrete ship has just been launched at a Pacific port in the United States, where others are in the process of construction; and it is believed that such ships will be built on a large scale. Although the durability of the reinforced concrete ship is still an undetermined factor, the claim is made that it would exceed the term of the war. In a large measure the durability of reinforced concrete ships will depend upon the action of the sea-water on the concrete and on the iron reinforcements.

During the past few years there has been considerable discussion regarding the durability of concrete, and there exists a certain amount of disagreement on the subject. There appeared in *Engineering News* of April 4, 1912, wherein is published a report of the American Society for Testing Materials' meeting, the following sentence: "The report of the waterproofing committee brought about some excited discussions, during which several persons affirmed their belief in the imperishability of concrete and protested against any hint of any other possibility." However, though "it is no doubt true that many diseases can be cured by a practitioner who strenuously denies their existence and thus encourages the patient to resist and overcome them, it can hardly be expected that defective concrete walls or disintegrating piers can be strengthened by 'absent treatment,' however vigorous be the denial of the injury or however prominent the denier." It is much better to look facts in the face and attempt to find a remedy.

## REACTION BETWEEN THE ALKALI SALTS AND THE CEMENT SILICATES

Sea-water, one of the agents which brings about the disintegration of concrete, attracted the attention of users of cement soon after it was first employed in marine construction. Although a great deal of non-reinforced concrete has withstood the action of the sea up to the present time, and will probably continue to do so, still some of it has failed. While the cause of this disintegration is not definitely known, Le Chatelier and others have pointed out that it can probably be ascribed to a reaction between the magnesium sulphate of the sea-water and the lime of the cement (formed during setting) and the alumina of the aluminates of the cement, with the resulting formation of magnesium hydroxide and calcium sulpho-aluminate, which crystallizes with a large number of molecules of water. Notwithstanding that the other components of sea-water have usually been supposed to have but little effect on

concrete, attention has recently been called to the fact that both sodium chloride and magnesium chloride rapidly react with the silicates in concrete<sup>2</sup>.

In the laboratory it is possible to destroy, almost completely, small cylinders or other forms of concrete or cement mortar by the action of solutions of various salts. The "action of the salts in alkali water and sea-water on cement" has been the subject of a lengthy investigation by Bates, Phillips and Wig, of the U. S. Bureau of Standards, and their results have been published<sup>3</sup> under the foregoing title. This investigation was undertaken in consequence of disintegration of concrete, through the action of water containing magnesium and sodium sulphates, occurring in several integration projects in some of the Western States; and for the purpose of ascertaining the action of various single and mixed salt solutions on concrete and cement. The salt solutions were allowed to percolate through hollow cement cylinders closed at one end, and it was found that any cement mortar may be destroyed if a sufficient amount of salt accumulates and crystallizes out. It was further found that, in general, chloride solutions were more effective than sulphate solutions in removing lime from concrete, but that mixed chloride and sulphate solutions were more effective than solutions of single salts.

## CRACKS DUE TO INCREASE IN VOLUME UPON RUSTING OF THE REINFORCING BARS

Several years ago the writer constructed a number of concrete blocks 3 ft. x 1 ft. x 1 ft., in which were imbedded several iron rods, and exposed them to the weather. A small quantity of sodium chloride was mixed in with the concrete. Gradually these blocks developed cracks which widened and spread as time went on; and today some of them have fallen to pieces, leaving the reinforcing rods in a badly corroded condition, while the others are badly deteriorated and iron-stained.

A striking example of the deterioration of marine reinforced concrete is to be found in Young's "Million Dollar" Pier at Atlantic City, New Jersey. At the end of two years after its completion, some of the piles commenced to disintegrate owing to the corrosion of the reinforcements. The disintegration proceeded so rapidly and the structure became so weakened, that in the winter of 1912 a large portion of the pier was swept away by a storm.

At the Key West extension of the Florida East Coast Railway, one of the steel reinforced concrete viaducts was found to have undergone extensive deterioration within two years after its completion, and in conse-

\*Read before the Faraday Society, July 23, 1918.

<sup>1</sup>Le Chatelier, *Tonindustrie Zeitung* 33, 931. Chandelot Clements et Chaux hydraulique, page 306. Michaelis, *Bul. de la Soc. d'Encourage de l'Industrie*, June, 1897.

<sup>2</sup>Chandelot (loc. cit.). Michaelis, *Bul. de la Soc. d'Encourage de l'Industrie*, 632, 1890. *Engineering Record*, July 20, 1910.

<sup>3</sup>Bureau of Standards, technical paper 12. *Journ. Franklin Institute* 175, 65.

quence, since 1909, all viaducts have been constructed without reinforcements, and with a cement low in magnesium and sulphuric acid and finely ground.

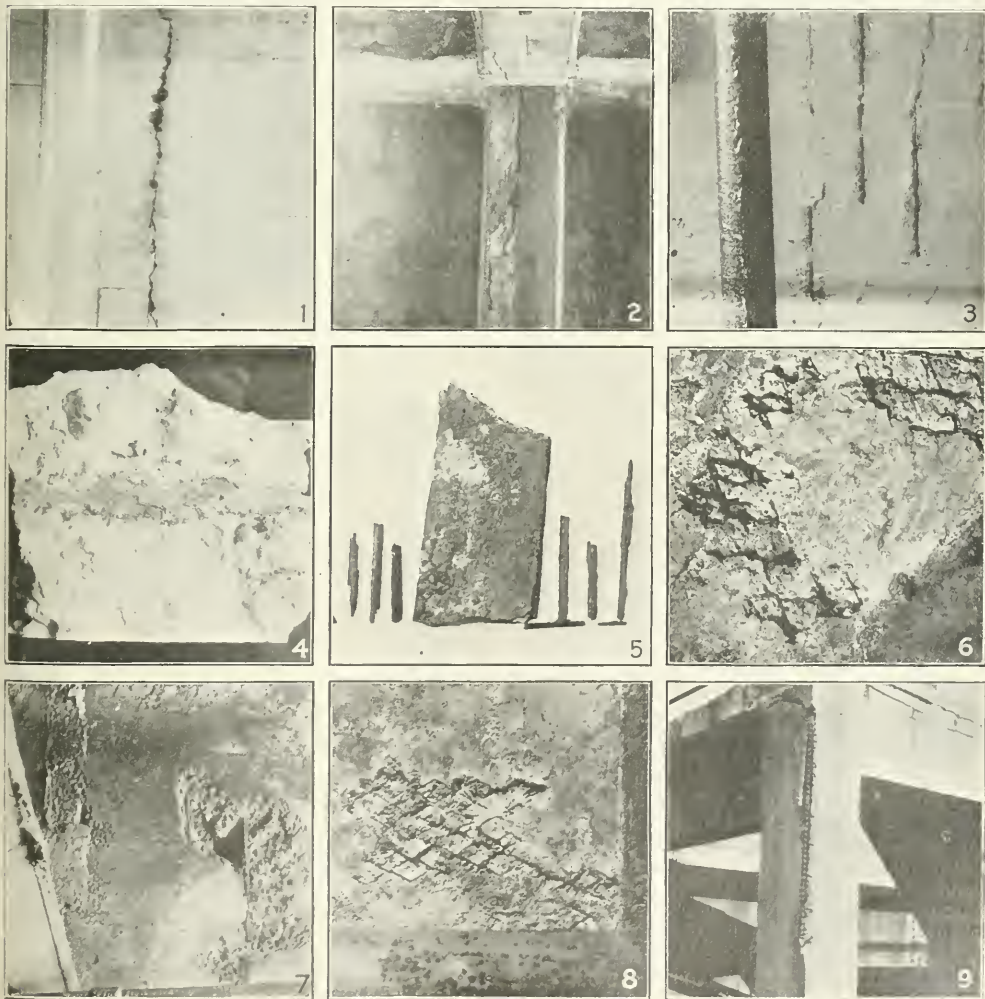
According to a recent report<sup>1</sup> by J. L. Harrison, District Engineer, Hoilo, the cracking of reinforced concrete structure is markedly prevalent in the Philippine Islands. A study of this trouble has demonstrated that not a single structure showing rusted steel has been free from salt, the percentage of which varies considerably. In view of this, engineers in the Philippines have been advised that not only is the use of salt water dangerous in concrete structures, but that beach sand and beach gravel should be employed only after having been thoroughly washed with fresh water.

<sup>1</sup>Bul. of Bureau of Public Works, Oct., 1916.

The foregoing, and many other similar pieces of evidence, indicate that salt, brine, and sea-water exert a deteriorating action on concrete.

The possible causes of the deterioration of ordinary concrete are bad cement, bad aggregate, bad proportions, bad mixing, external violence, wear and tear, and the action of saline solutions; while for reinforced concrete, in addition to the foregoing causes, there are corrosion of the reinforcements either directly or by electrolysis, and cracking due to monolithic character, or possibly to stresses between the concrete and the reinforcements.

As this paper deals chiefly with the corrosion of iron reinforcements of concrete due to the action of brine, the probable reactions which occur when this metal comes in contact with a salt solution will be discussed briefly.



ILLUSTRATIONS OF BREAKS IN REINFORCED CONCRETE CAUSED BY CORROSION

Fig. 1—Ceiling; 2—Beam; 3—Wall, embedding concrete falling away; 4 and 5—Corroded reinforcing bars; 6, 7 and 8—Metal lath corrosion; 9—Platform and pillar disintegrating

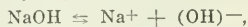


## CORROSION OF IRON DUE TO ELECTROLYSIS

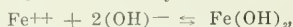
When a piece of iron is placed in distilled water, it becomes negatively charged, since its electrolytic solution pressure (which is equal to  $1.2 \times 10^4$  atmospheres) causes atoms of the metal to enter the water as positively charged ions leaving an equivalent number of negative charges behind on the bar of metal. In spite of this large electrolytic solution pressure, only a vanishingly small quantity of the iron passes into the water in the form of ions, and consequently the metal bar receives but a correspondingly small negative charge. This is due to the fact that when a ferrous ion with its large positive charge ( $2 \times 96,500$  coulombs for every gram ion of the metal) leaves the bar of electrically neutral iron, the latter acquires a negative charge of corresponding magnitude; it therefore becomes more difficult for a second ferrous ion to enter the water, owing to the attraction between unlike charges of electricity; and it is still more difficult for a third ferrous ion to leave the metal, and so on. Consequently, very soon the negative charges upon the bar of metal become sufficient to prevent further ferrous ions entering the water, and equilibrium sets in; and, unless these negative charges are removed from the metal, no more iron can pass into the water. But suppose, now, that common salt be added to the water containing the bar of iron. On dissolving, this electrolyte largely dissociates into its ions, and it may be assumed that hydrolysis takes place although to a very limited extent, in accordance with the equation—



The concentration of these new substances being extremely small, they dissociate practically completely, and give rise to negatively charged hydroxyl ions and positively charged hydrogen ions:



The hydroxyl ions then unite with the ferrous ions that have passed into the solution from the bar of metal to form undissociated ferrous hydroxide:



which gradually precipitates as an hydrated oxide. The presence of dissolved oxygen in the solution would, of course, gradually convert the oxide and ferrous hydroxide into the corresponding ferric compounds.

The negative charges upon the bar of iron, which were in equilibrium with the ferrous ions before the addition of the sodium chloride, now attract the positively charged hydrogen ions, the electrolytic solution pressure of hydrogen being much less ( $0.9 \times 10^{-4}$  atmospheres) than that of iron and very much less than that of sodium ( $>10^4$  atmospheres), and, in consequence, hydrogen ions move toward the negatively charged iron bar, touch it and become neutral gaseous hydrogen atoms. The negative charges upon the bar being thus diminished, more iron enters the solution in the form of ferrous ions, and the foregoing process occurs again, and so on. In this way the bar of iron gradually disappears and iron oxide and hydrated oxide accumulate.

The nascent hydrogen which is produced on the bar may be absorbed by the iron; it may be oxidized by the oxygen dissolved in the solution, or it may be liberated as a gas.

Some of the preceding steps have been demonstrated by the writer. In order to determine whether gaseous hydrogen is ever liberated under the foregoing conditions, a number of pieces of iron were immersed in dilute aqueous solutions of sodium chloride contained in glass tubes with a capillary top, and connected at the bottom with a small glass tube bent upward at right angles. Before being introduced into the glass tubes, the salt solution was boiled to remove the air, and afterward, before sealing off the tip of the capillary, a high vacuum was applied to the solution for some time. It was found that in all the tubes a greyish-green deposit slowly accumulated near the bottom, and at the end of several months a small quantity (0.1 to 0.2 cc.) of gas had formed in three of the tubes. This gas proved to be mostly hydrogen. In an investigation on the electrolytic decomposition of iron which is still in progress, it has been found that considerable quantities of cream-colored ferrous hydroxide may be produced under conditions analogous to the foregoing.

In addition to the corrosion of iron through the action of brine by the process just outlined, auto-electrolysis only occurs on account of the electrical potential differences which exist in commercial forms of iron due to the presence of segregated impurities. These differences, which are augmented by chlorides of the alkali metals, bring about a galvanic action that causes the iron to go into solution at certain points with the formation of oxide.

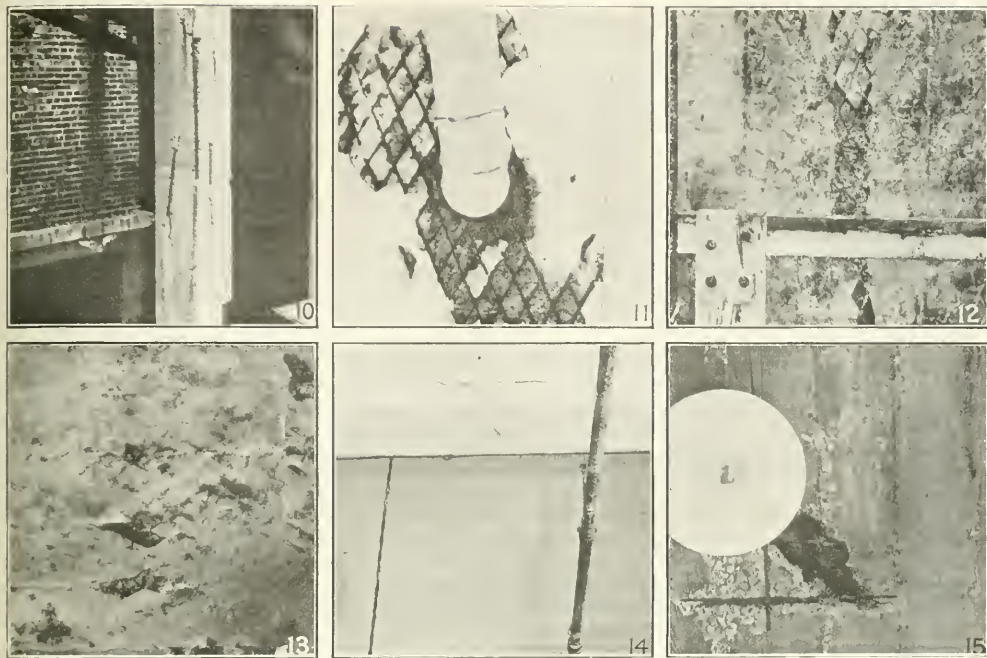
From what has been said, it should be clear that reinforced concrete which comes in contact with brine or sea-water will commence to deteriorate as soon as the brine comes in contact with the reinforcing rods; for, as both iron oxide and the hydrated oxide occupy a larger volume than the corresponding amount of iron, there will be developed an enormous expansive force, which is sufficient to crack the strongest concrete and force it away from the reinforcing rods. The more porous the concrete, the more rapidly will this disintegration set in. Indeed, the writer is familiar with cases of cinder concrete structures, in contact with brine which have shown signs of advance deterioration at the end of the year after their completion.

## WATER PROOFING PROCESSES NOT PERFECTED

Regarding the water-proofing of concrete, it should be pointed out that an impervious concrete is seldom obtained outside the laboratory. The average concrete is practically never waterproof. Although there are many substances on the market for rendering concrete waterproof, the majority of them are far from satisfactory. A number of such substances have been investigated by Brown<sup>1</sup>, who points out that all waterproofing materials will sooner or later hydrolyse, crack, or disintegrate. About a year ago the City of Philadelphia, upon the recommendation of the Franklin Institute, awarded the John Scott Legacy Medal to Max Ulrich Schoop, of Zürich, for his invention, the Schoop Metal Spraying Process. By means of this process various metals can be sprayed under high pressure upon any slightly roughened surface so as to form a smooth, adherent skin. After examination of the results produced by the Schoop process, the writer is of the opinion that by this means

<sup>1</sup>The Electrician, 69, 915 (1912).





ILLUSTRATIONS OF BREAKS IN REINFORCED CONCRETE CAUSED BY CORROSION

Fig. 10—Badly shattered pillar due to corrosion of reinforcements. Figs. 11 to 15—Illustrate cases similar to those previously shown

concrete might easily be rendered impervious to water or brine.

#### PAINTING THE REINFORCING RODS

It has often been suggested that the deterioration of reinforced concrete through electrolysis might be prevented by the use of protective paints upon the metal that is to be imbedded in the concrete. A few years ago, the protective action of a large number of paints was very thoroughly studied by Gardner<sup>4</sup>, who points out that if the reinforcements are treated with suitable insulating and bonding paints before they are imbedded in the concrete, the causes which contribute to electrolysis will be guarded against and concrete structures will be rendered safe from deterioration through corrosion of the reinforcements. From the results of his investigations, Gardner concludes that the vehicle of such paints should contain: boiled or bodied oils or products which dry to a fairly saturated film, oils which dry by semi-polymerization rather than oxidation, and oils which dry to a flat rather than a highly gloss surface; while the pigment should contain a percentage of: pigments which are coarse and which, therefore, tend to form films having a rough surface, pigments which are inert and which do not act as conductors of electricity, and pigments which are either basic or of the chromate type. The metal should be sanded if possible.

#### EXAMPLES OF CONCRETE DETERIORATION

Since most concrete is more or less porous to moisture, and since iron undergoes gradual decomposition in the presence of salt water, with consequent expansion in

volume, it is to be expected that reinforced concrete that comes in contact with brine, sea-water, or salt and moisture will ultimately disintegrate. It is not surprising, therefore, to find reinforced concrete piers, sea-walls, and buildings in the neighborhood of the ocean in various stages of deterioration.

Today large reinforced concrete structures are used to house industries that employ large quantities of salt and brine, which are constantly spilled on the floors. In order to ascertain whether the concrete of such buildings had undergone any deterioration, the writer a few years ago examined a large number of them in many different cities throughout the United States; and in this paper he wishes to give a brief account of some of the cases of deterioration observed at that time. In practically all the buildings inspected, reinforced concrete floors which came into contact with brine had iron-stained cracks on the under side. These cracks, which nearly always ran parallel to the reinforcing rods, were usually very narrow, but they indicated, nevertheless, deterioration of the reinforcements, and would continue to grow as the disintegration of the iron progressed. Fig. 1, which is a photograph of a ceiling of a large reinforced building in Detroit, the floors of which are continually wet with brine, is a typical example of one of these iron-stained cracks in the early stages, and Fig. 2 shows a cracked horizontal beam supporting the floor of a reinforced concrete building in Chicago. In many instances, where the deterioration had been in progress for some time, the cracks were found to vary from  $\frac{1}{4}$  in. to  $\frac{1}{2}$  in. in width, and in some cases the deterioration had progressed so far that large pieces of

<sup>4</sup>Gardner. Journ. Franklin Institute, 179, 313 (1915).

concrete had fallen, or were about to fall, leaving badly corroded reinforcements exposed, as illustrated in Fig. 3 (photograph taken in Buffalo). An examination of a number of pieces of this fallen concrete showed that in every case a quantity of iron oxide adhered to the concrete where it had come in contact with the reinforcing rods (Fig. 4), and that it was sometimes as thick as  $\frac{1}{2}$  in. Where the concrete had broken away from the reinforcements, the latter were usually so badly corroded that it was possible to remove thick layers of oxide with the fingers. In a few cases the deterioration had progressed to such an extent that the reinforcements had been completely converted into oxide. Fig. 5 shows pieces of iron oxide,  $\frac{1}{2}$  in. to  $\frac{3}{16}$  in. thick, which were pulled away from corroded reinforcements or beams with the fingers.

A few details regarding particular cases of deterioration observed in some of the reinforced concrete structures examined may be of interest.

The ceiling of a machine-shop of a reinforced concrete plant in East St. Louis was found to be very badly damaged. This building, at the time of inspection, was about ten years old. The upper side of the ceiling was continually wet with brine, which continually leaked through to the under side and wetted it in a number of places. On this ceiling large brown iron-stains were numerous, and in at least twenty places pieces of concrete had fallen, leaving badly corroded net-iron reinforcements exposed. In one place, a piece of concrete 12 ft. long and varying from 2 in. to 18 in. in width had broken away. The reinforcements of this ceiling were imbedded at a depth of about  $\frac{3}{4}$  in. from the surface. Photographs of this ceiling are shown in Figs. 6, 7 and 8. Examples similar to these have been observed by the writer in Chicago, Kansas City, Detroit, and Buffalo.

At a plant in Kansas City that were found several very interesting cracked reinforced concrete pillars which supported a reinforced concrete platform at the top of an outside staircase. Large quantities of salt were used in the plant, and the platform was often wet with brine. The cracks on these pillars ran parallel to the longitudinal reinforcing rods. In some places the concrete had fallen away from the rods, which were badly corroded, and in other portions of the concrete were easily pulled away. Photographs of these pillars are shown in Figs. 9 and 10.

At another plant in this city there was a long outside platform, from which cars were loaded, covered by a reinforced concrete roof. At one end of this roof there was a pile of rock salt, which was partially protected from the weather by a wooden roof. Rock salt had been stored in this place for years. For a number of yards beyond where the salt was stored it had been spilled continually on the concrete roof, and owing to rains, perhaps a quarter of the roof was frequently wet with dilute brine. On the under side of the roof, directly below this place, there were many brown iron-stains, wet patches, salt deposits, and in one place the concrete had fallen, leaving the net-iron reinforcements exposed. These had deteriorated to such an extent that the outer portions crumbled on touching and some of the rods were easily pulled away. The area from which the concrete had fallen was at least one square foot. The individual rods of the exposed net-reinforcing, originally about  $\frac{1}{2}$

in. in diameter, had increased to about  $\frac{3}{4}$  in. in diameter, owing to the conversion of the iron into oxide. Some of these rods had disintegrated to such a degree that the sound iron core was less than  $\frac{1}{16}$  in. in diameter. Near where the concrete had fallen, it was evident that the expanding reinforcements were gradually forcing the concrete downward. At the far end of the ceiling, where salt had not been spilled above, there was no evidence of deterioration and the concrete was in an excellent condition.

At a third plant in Kansas City, a five-year old reinforced concrete basement ceiling was found to be in a very bad condition. This ceiling was reinforced with 3-in. twisted iron rods. The floor above was more or less wet all the time, and in places salt came in contact with the water, forming brine. There were many cracks on this ceiling, some of which were sufficiently wide to insert a lead-pencil. One such crack was 20 ft. to 30 ft. in length. In several places large pieces of concrete had fallen, leaving corroded reinforcements exposed. In one place a large piece of concrete which was almost dropping and which weighed about 25 lb. was easily pulled away from the reinforcements. The under side of this, as is usually the case, had a large portion of the corroded reinforcements adhering to it.

The writer examined a building in Kansas City which contained a large quantity of reinforced cinder concrete that came into contact with considerable amounts of brine. This concrete, which was thirty years old, was in a very damaged condition, and in many places very large pieces had fallen.

In one of the Chicago plants examined, a whole floor had collapsed about a year previously, owing to the weakening of the reinforcements by disintegration.

Similar cases to the foregoing have been found by the writer in a number of cities in different parts of the country. Excellent examples of deterioration of reinforced concrete found in Buffalo are shown in Figs. 11, 12, 13 and 14.

#### WINTER POURED CONCRETE SHOULD NOT BE SALTED

When concrete construction is carried out in winter, it is sometimes the practice to add salt to the concrete to prevent freezing, often as much as 20 per cent being added. The writer has examined a number of reinforced concrete structures where salt had been mixed with the concrete during construction. As is to be expected, where the concrete comes in contact with water or moisture, there are manifold evidences of deterioration; but, on the other hand, where the concrete has been kept dry no damage has been observed. An example of deterioration due to this cause is shown in Fig. 15.

Examination has been made of a number of reinforced concrete tanks used for storing both water and brine. In all of these tanks it was observed that the liquid slowly percolated through the concrete, that the inside surface of the tanks was soft, and that, although these tanks had only been in use for less than a year, the strength of the concrete was much less than the normal strength. These effects were much more marked in the tanks which were used for storing brine.

The following conclusions are drawn by the writer from his investigations of the action of salt, brine, and sea-water on reinforced concrete:



1. All concrete which is not waterproofed in some way is more or less porous to water and brine.

2. Brine readily softens the surface of concrete, and, therefore, more easily penetrates to the reinforcements, on which it exerts a disintegrating action that, owing to the attendant expansion, gradually weakens the concrete, causing it to crack and split, and in some cases to fall away from the reinforcements.

3. The more porous the concrete, the more rapid the disintegration of the reinforcements through the action of brine.

4. Reinforced concrete floors which come in contact with brine will gradually develop leaks. These will be followed by incrustations of discolored salt on the under side, where, later, iron-stained hair cracks will develop, running parallel to the reinforcements. As the deterioration progresses the cracks will widen, and, owing to the great expansive force of the accumulating iron oxide, the concrete will be gradually pushed from the corroded reinforcements and ultimately fall.

In view of the foregoing conclusions it is evident that reinforced concrete immersed in brine or sea-water is liable to subtle and persistent deterioration, due to electrolytic action between the salt and the reinforcements. Therefore, the permanence and durability of reinforced concrete ships is a matter of considerable doubt, unless the sea-water is prevented from coming in contact with the reinforcements. Such prevention may be effected by coating the reinforcements with the protective paint, such as has been described, or by applying to the outer surface of the concrete some material which will render it waterproof. Since most of the substances which have been used for this purpose give results which are far from satisfactory, the writer suggests that good results might be obtained by coating the concrete with a very thin layer of a suitable metal by means of the Schoop Metal-Spraying Process. Finally, concrete that is to be used in the construction of ships should undoubtedly be made from cement of fine pulverization, low in alumina and high in silica, free as possible from gypsum, absolutely free from lime, slow in setting and quick in hardening.

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## War Department Authorizes Construction of New Plants

Authorization to proceed with the following building has been given to the Construction Division of the Army.

The construction of a phosphorus plant at or near Fairmont, West Virginia. The estimated cost is \$500,000 and the contract has been let to the American Phosphorus Company.

The construction of a tetryl plant at Senter, Michigan. The estimated cost is \$250,000. The foregoing amount is divided into the cost of the construction of the necessary buildings and equipment, included in which will be the boiler and power houses, facilities, packing houses, magazines, tramways and, in fact, everything to make a complete plant.

Additions and extensions to the Frankford, Penn., arsenal have been begun under the direction of the Construction Division. It is estimated that these will cost

\$1,000,000. The work consists of the extension of the loading room, annealing rooms, action press shop, barrack buildings, additional storehouses, stable, carpenter shop, a forging plant with equipment, a sea-wall along Frankfort Creek and other work to facilitate the production program at this point.

## Furloughs and Deferred Classification for Chemists

The Chemical Warfare Service has been duly authorized, by order of the Secretary of War, to make the necessary arrangements through the Adjutant General's Office to secure furlough, without pay or allowances, of such chemists as are necessary in such Government Bureaus as the Bureau of Standards, Bureau of Chemistry, Bureau of Mines, United States Patent Office, where such chemists are engaged in chemical work for the Government, or State Bureaus concerned, essential to the prosecution of the war. At the same time they are advised that the new Selective Service Regulations to be published shortly, will emphasize to the draft boards the fact that skilled employees of war industries should be placed in deferred classification. The induction into the military service of skilled men necessary to essential industries or occupations, to be subsequently furloughed back to their industries or occupations, involves an expense to the Government, and the men concerned lose time from their necessary work. The Bureaus concerned are authorized by the Selective Service Regulations to submit to the draft boards affidavits and written proof to maintain their contention that their employees should be placed in deferred classification and it is believed that they should be encouraged in securing deferred classification rather than securing the furlough of the men after they have been inducted into the military service. Communications relative to the matter should be addressed to Major Victor Lehner, C.W.S., 7th and B Streets, Washington, D. C.

## Carborundum Refractories

The article on this subject by Mr. C. S. Linbarger published in our daily issue for September 27 was originally presented at the meeting of the American Ceramic Society, New York City, September 26. Through an oversight we failed to give the customary credit to the Society, and due acknowledgement is made herewith.

## Imports of Rubber to January 1, 1919

The previous rate of permitted importations of crude rubber, effective up to Oct. 1, 1918, has been continued by the War Trade Board, in a new ruling (W. T. B. R. 248) for the final quarter of the year. Importations of crude rubber from overseas during the months of October, November and December, 1918, will therefore be limited to 25,000 tons, or at the rate of 100,000 tons a year. One-fourth of this amount will be licensed only from Central and South America. The remaining three-fourths may be licensed from any country. The amount so permitted to come forward will be allocated by the Bureau of Imports along the general lines of the previous allocations (Rulings 115 and 238).



## Development of the Magnesium Industry\*

BY LEONARD WALDO

IN THINKING over this subject the question arises whether there is, as yet, a development of the Magnesium industry on any such scale as we American engineers would call a development. I think of the time 35 years ago when in the Cowles works at Lockport, we had first harnessed Niagara at the overflow of the Canal Locks and had commenced with much fanciful hope the production of aluminium, which was, with its lightness going to decrease the weight of railroad carriers and metal structures by two thirds, and, because of its universal presence in the earth's crust was to displace the less abundant and heavier copper and iron, in many engineering enterprises.

Alas, the unthought of prevailed; the inertia of the world's customs, traditions and industrial practices made for a delay of years until aluminium should find its place and its comparative qualities should be widely known. Then the opening for its use occurred in a totally unexpected direction. It was found that the quality of steel could be improved by its use and thereafter a sufficient quantity of aluminium was produced to place its manufacture on a marketing basis, until now with the war demand, it is probable the annual production in our country of the Aluminum Co. of America amounts to 400,000,000 lb.

With this example of trade inertia before us, it is not surprising that magnesium would have to seek its natural applications before its manufacture could be placed on a basis at all commensurate with the more important metals. We find that in 1883 for instance, the European price of magnesium of 99.7 per cent purity was \$32.43 per lb. and that in 1902 with a world's output not far from 2500 lb. the price per lb. was \$2.82, approximately the price at present fixed by the United States government.

Magnesium has been known to metallurgists as a Cinderella sister to aluminium. It had such greater powers as a de-oxidizer in steel practice that the first attempts to use it commercially resulted fatally to the workmen. In action with the thermit process, it again showed uncontrollable vigor. In weight it is but 63½ per cent as heavy as aluminium and weighs 109 lb. per cubic foot. It exceeds in electric conductivity an equal weight of aluminium. It has a more beautiful color and is stronger than aluminium. Its specific heat is very high, ranging from 0.24922 between 20 and 100 deg. C. to 0.43516 at 625 deg. C., more than twice that of iron. Its oxide fuses at a temperature higher by 800 deg. C. than alumina. Peculiar and unexplained phenomena were noticed in the combustion of magnesium in the air. Woods showed that more heat was developed for equal amounts of oxygen taken up than in the case of any other known metal.

### COMBUSTION OF MAGNESIUM FOR LIGHT

Rogers as early as 1892 announced that the spectrum of burning magnesium more nearly resembled that of the sun than did any artificial illuminant; although the character of the spectrum, if it is due to ordinary in-

candescence, corresponds to a temperature of nearly 5000 deg. C.; while the radiant energy emitted is 75 per cent that of the total heat of combustion, and the light-giving power of magnesium per unit of energy expended is from 50 to 60 times that of gas. Later Nichols showed that incandescent magnesium emits light under conditions different than carbon and that it is more like the sun than that of any other source; that it is ten times as brilliant in the violet as the gas flame for equal luminous intensities, and one-half less in the red; also it surpasses that of the arc lamp in the yellow. Nichols assumes that here the law of radiation differs essentially from that of the ordinary incandescence. Can it be that we are encroaching on the ground of light production without the corresponding emission of heat? It is to be hoped that the activity of the U. S. Bureau of Standards along the lines of light emissivity as connected with the temperature of the highly refractory oxides, may not have to be curtailed on account of other war work researches, since it has a direct bearing on illumination for making photographic records of our war operations.

### COMBUSTION OF MAGNESIUM FOR RAPID THERMAL EXPANSION OF GASES

Closely connected with the luminescence of magnesium combinations is that of its relation to high military explosives. Its quickness of action in depriving nitrates, chlorates, manganates, sulphates and peroxides of constituent parts of oxygen with the accompanying extremely high temperatures instantly effective for expanding the volume of the released gases and other volatilized constituents gives magnesium a position among the best of explosive agents.

Here again we would be greatly benefited by a greater knowledge of the chemistry and physics of high temperatures; in fact, we know very little of the reactions taking place above, say, 1200 deg. C. in metallurgy. The few things we have discovered in these high-temperature regions are so helpful to war efficiency that it would be good if our researches were more extended in this difficult field. For example, the whole theory of the formation of the compound carbide of chromium, tungsten, and iron and their freeing at high temperatures to prevent the reversion of the reaction is the very basis of high-speed tool-steel production and hence the production of heavy ordnance on the lathe.

I cannot, for obvious reasons, at this time and place go into details as to present processes or results. I have mentioned these two recent applications of metallic magnesium to show that here we have an unexpected development, which sufficiently increases the demand for the metal to warrant the necessary capital, diversions of water-power and competent engineering to supply an amount large enough to tax present facilities and to encourage their rapid extension. We have, therefore, in the use of magnesium as an illuminant and as an explosive, the analogue to the use made of aluminium as a so-called deoxidizer in the case of steel. It is possible now to dismiss the market question for magnesium and consider some of its other uses.

### USES OF MAGNESIUM IN ALLOYS

For the last ten years or more, the cupro-magnesium alloys for scavenging brass have been a successful

\*A paper read at the Fourth National Exposition of Chemical Industries, New York, Sept. 27, 1918.

marketable product and thanks to our own brilliant and lamented Edwin Star Sperry, they obtained a place in copper alloy furnace work. The cost however limited their use. Probably with the present needs of greater economy in saving wastes in the casting shop and the higher prices obtained, the use of cupro-magnesium can now be put on a profitable basis as also the collateral use of metallic magnesium for controlling the pitch of copper in the reverberatory.

It was fortunate that in the establishment of the manufacture of magnesium by the Cunniff Brothers at Rumford Falls, Me., that a process for recovering the metal from a pure magnesia by-product was adopted. The early development of aluminium had been greatly hindered by the use of impure materials, and it is said by engineers to-day that the manufacture of aluminium sufficiently pure for modern metallurgy is entirely a question of making pure alumina. Modern alloys require a purity on a par with lake or electrolytic copper, Bertha zinc and Straits tin. The early aluminium alloys suffered greatly from such impurities as iron, silicon, and sodium. The present magnesium alloys fortunately are starting with an all but c.p. magnesium.

Of the flotilla of alloys using magnesium now streaming into the ocean of commerce, some have already been long enough in service to show what time, vibration, gaseous corrosion, alternate stresses, and water-vapor both on sea and land will do for them. Notable among these are "magnalium," of which there is a description in *Engineering* (London) for Jan. 5, 1906, and "duralumin" as described by Wilm in *Metallurgie* for 1911, pages 225-227.<sup>1</sup>

In these alloys, the specific gravity is kept near the 2.75 of pure aluminium. In other commercial alloys sold as aluminium, the specific gravity of the pure aluminium is increased by the addition of zinc or copper to about 3.2; but by the use of magnesium to replace such zinc or copper, the specific gravity would be somewhat reduced and we would have commercial aluminium alloys of 81 lb. replacing the same sizes of present aluminium of 100 lb. weight.

Some of the alloys of magnesium with aluminium are of extreme beauty; notably those which correspond to the eutectic, which is formed when the metals are combined in nearly equal proportions, the color of which is an ultra silvery whiteness and the texture, when the final meltings are made free from occluded gases, of microscopic fineness. This series is of great value for reflection of light in telescopes, in plane and curved mirrors. Because of its brittleness, an alloy of equal or nearly equal proportions lends itself to those powdering process where rotating hammers or stamp mills are used. Here, as in all processes for mixing powdered magnesium precautions are necessary to avoid explosions.

Years ago at Bridgeport we made certain small ingots for unknown but cash-paying customers, of rich-colored yellow aluminium bronze. Months later, we identified those same ingots in the police court after having been sold for genuine gold bricks. I am reminded of that occurrence as I think of the opportunity for the magnesium business now that this beautiful metal has come to stay, and is being made, to insure

purity and rapid production, from such costly sources as the magnesium-potassium alkali-chlorides, where there is but 7.3 per cent of metal available or of other chlorides where there may be 10 per cent! Think of the magnesian ophiolite in Canada with its 42.5 per cent bulk of magnesium, or of Salt Lake, Utah, with its 0.56 per cent of magnesium, or of Old Ocean himself with his  $\frac{1}{2}$  of 1 per cent at our feet. As for other sources, besides carnallite (natural or artificial), we have kieserite, magnesite, dolomite and in fact some 51 out of 768 minerals, and the bitters of the sea in collecting sea-salt. In ordinary sea water, a cube of 30 feet dimensions contains a 2240-lb. ton of magnesium.

Current production, with two plants of the American Magnesium Corporation at Niagara Falls, N. Y. and Rumford Falls, Maine, formed by the merging of the company of that name with the Rumford Metal Co., may be considered larger than that for the first half of 1918, which according to the United States Geological Survey was 116,938 pounds.

The time has not yet come for the prototype of Captain A. E. Hunt's classical paper on the "Manufacture of Aluminium by Electrolysis and the Plant at Niagara for its Extraction" published in the *Proceedings* of the Institution of Civil Engineers in 1896, but within a few years to come, with war conditions removed, it will be possible to reveal to the full the technique of production and the power and capacity in manifold directions of the most attractive of all metals—magnesium.

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The President has approved the maximum prices on sulphuric and nitric acids, fixed at a meeting between the Price Fixing Committee and the manufacturers on September 26, 1918, these prices being effective from September 30, 1918, to December 30, 1918.

### Control of Tin Imports

B. M. Baruch, chairman of the War Industries Board, announces that under the recent decision of the War Industries Board to take control of the domestic pig tin situation by a license system the United States Steel Products Company only will be granted import licenses, this company to act under government direction and in the interest of consumers.

All users and dealers in pig tin will be licensed, and will secure their future requirements of pig tin from the United States Steel Products Co., which will make distribution under the direction of the War Industries Board.

The Inter-Allied Tin Executive, who will carry out the terms and agreements of the Inter-Allied Pig Tin Pool recently arranged in London, will control the buying price in each producing market. The War Industries Board will control the prices and terms under which the pig tin is to be sold to the domestic users and dealers.

Preliminary to the issuance of licenses to the users and dealers in pig tin an inventory of stocks on hand and contracts unfilled by the 2000 odd individuals and plants affected is being made by the Tin Section of the War Industries Board. If necessary, there will be a re-distribution of the stocks on hand to equalize them according to essential uses.

<sup>1</sup>See also this Journal Oct. 1 and 15, 1917. *Aluminium and its Light Alloys*, by Paul D. Merica.



FIG. 1.—THE PLAZA AND HILL RESIDENCE  
FIG. 3.—PHELPS DODGE MERCANTILE CO. STORE  
FIG. 5.—NEW TYPE G HOUSE

FIG. 2.—TYPE H HOUSE; FLOWER BEDS AND WAR GARDENS  
FIG. 4.—OLD TYPE G HOUSE  
FIG. 6.—"THE HILL" RESIDENCES FOR AMERICANS



## Housing at Tyrone, New Mexico

An Account of the Systematic Efforts of the Phelps Dodge Corporation to Provide Wholesome Living Conditions and Harmonious Surroundings for Its Employees—Not An Experiment in Philanthropy, but a Wise Business Policy

By CHARLES F. WILLIS

Consulting Supervisor Department of Industrial Relations,  
Phelps Dodge Corporation

IT IS BELIEVED that when the engineers of the Phelps Dodge Corporation first investigated the property now known as their "Burro Mountain Branch," the attractions of climate and the environment of Tyrone must have entered into consideration, for today this place may be described by an adjective that seldom fits a mining or smelting community—it is a charming spot.

Were it not for the newness of the buildings, one could almost imagine that he was in a prosperous town in old Mexico. The buildings carry out the extreme Spanish type of architecture, with their plastered walls in various pale tints of blue, pink, gray and tan, the plaster laid unevenly as was done in the days when plasterers were not as skillful as at the present time, the roofs of vari-colored tile, everything Spanish to the last detail. One would imagine that the buildings were all of adobe until he watched a new building in the process of construction and saw the wooden frames, the wire lath on the outside and button board on the inside. The charm of the Spanish type is there, however, in the crooked corners of the window casings, the "hand hewn" timbers, aged with burnt umber, and, true to type, we further find that most of the buildings are occupied by Mexican laborers.

### GENERAL LAYOUT OF VILLAGE

It is indeed fortunate that this property was purchased by an organization with broad policies, as it would have been a pity to have put an ordinary camp in the site which Tyrone occupies. The long, broad valley of the Mangus River, eleven miles out of Silver City, formed the axis line for the center of the town, and from this valley at right angles, several smaller valleys branch, of sufficient size, however, to provide for the laying out of a street with houses on both sides. One picture a typical street of an industrial community as a row of box-like houses, all alike on the outside and with interior details identical. As is shown by an inspection of Table I, this has been avoided in the Tyrone project by the adoption of some twenty odd houses, the types so scattered that it is unusual to find two alike in the same neighborhood.

The town was primarily laid out in sections. The community center is of course the plaza, surrounded by a group of fine buildings. Radiating from this are numerous canyons, each assigned to a definite purpose. On the southwest is Pinal Street, the lower end of which is built up with what is known as Type G, H, K, and J apartments. These two- and three-room houses, shown in Figs. 4 and 5, are designed to be rented to Mexican laborers who wish homes at low rentals—from six to

twelve dollars monthly. The upper end of this street is surveyed in lots to be leased to Mexicans at a very nominal rental, where they may build their own homes. On the west side, leading directly out of the park, is Bellotal Avenue, bordered by similar houses for the Mexicans, as well as by a branch canyon from Bellotal Avenue, called Encinal Street. On the northwest side of the square is Fortuna Street, which leads up another canyon divided into lots which are leased to Americans with a \$1000 building restriction. On the southwest side is Coronado Street, subdivided for Americans into lots with no building restrictions. Leading from the plaza and winding up and over the hills to the mine is what is known as "the Hill," and along the well-graded roadway are fine residences for Americans. As seen in Fig. 6, there is no regularity as to their location or their setting, and they are of many different types.

### PHELPS DODGE POLICIES

Tyrone is distinctly a company-owned town; no land has been sold nor is it planned to sell any. There are advantages and disadvantages in living in a company-owned town, depending upon the policies of the company; fortunately for Tyrone the Phelps Dodge Corporation is particularly liberal. The store of the company (Fig. 3) is located in a prominent place on the plaza, but almost directly opposite is the fine building shown in Fig. 7 which has been leased at a very low figure for an independent store, in order to give their own store competition. This is the case in all lines of business, competitors being supplied with the necessary quarters to compete with Company enterprises. Every effort is being made to make it a town where the cost of living is low and to a great extent these efforts have been rewarded. The policy of the company is to have satisfied workmen who will stay with them year after year, who appreciate homes and who know that the company cares for their well being as well as for the profits from their properties. It is not by any means an experiment in philanthropy, but rather a policy of far-seeing men who recognize that the development and building of the community simultaneously with their business will bring greater profits, indirectly, but surely. They believe that it will pay dividends in content and in the reduction of labor turnover.

### THE PLAZA

The plaza is surrounded by a group of fine business buildings, harmonious in type of architecture, but all different in detail. On the east side is the company office building (Fig. 8) containing the offices of the officials, the townsie department, and the engineering,



FIG. 7.—INDEPENDENT STORE  
FIG. 9.—PUBLIC SCHOOL  
FIG. 11.—THE JAIL

FIG. 8.—OFFICES OF THE PHELPS DODGE CORPORATION,  
BURRO MOUNTAIN RANCH  
FIG. 10.—RAILROAD STATION AND POST OFFICE  
FIG. 12.—PINAL ST.: HOW MEXICANS LIVE WHEN LEFT  
TO THEMSELVES

bookkeeping, and auditing departments. On the northeast corner is the independent store, a confectionery, a refreshment parlor, a barber shop, a doctor, a dentist, a lawyer and a photographer. On the northwest side will be the employees' club house, yet to be erected. Beside the club house is a large school (Fig. 9) and in spite of the fact that the town has only four thousand people, it is reputed to be the best school house in the state of New Mexico. That Tyrone is being selected by workers as a place to bring up their families is evidenced by the attendance at the school. Although it was designed to be large enough for some years to come, the six hundred students attending last year made it necessary to erect an addition. The building was built by the company and leased to Grant County at a very nominal rental.

On the west side of the plaza is the department store of the Phelps Dodge Mercantile Co. (Fig. 3), and while large centers of population may boast of stores of greater floor space, they cannot boast of a more beautiful building. On the southwest corner is the railroad station and post office building, both of which are fitted to carry out the same general scheme, while on the southeast is to be the hotel, work on which has been stopped for the period of the war. Situated but a short distance away from the plaza and yet readily accessible to it is a garage, a large restaurant and a moving picture theater, and the company has even taken upon itself to build the "hoosegow" or jail in a pretty little park (Fig. 11). A central heating plant provides for all of the buildings surrounding the plaza and for carrying out the Spanish type of architecture; where steam radiators would seem out of place, the radiators are carefully concealed in the walls, under the seats in the station, and by various ingenious devices. The plaza itself is a beautiful spot with large grass areas, and will soon be equipped with the necessary band stand. The absence of "keep off the grass" signs is noticeable, the management believing that grass plots are made to use rather than to see.

#### DETAILS OF THE HOUSES FOR LABORERS

In the type of houses designed for the Mexican labor there are electric lights, sewer connections, water and gas. The type G house has six two-room apartments, which rent for \$6 per month; type H is a double two-apartment house renting for \$8 per month; type K has two three-room apartments which rent for \$9 per month, while type J is a single three-room house renting for \$12 per month. The other types vary from two to six rooms, renting at about \$5 per room. Types G, H, J, and K houses have flush toilets on the outside as a separate structure, although in the latest type G they are inside. Each room has electric plugs for iron, toasters, percolators and other electric devices. The earlier houses have cement floors in both the front and rear rooms, but the latest have wooden floors in the front and cement in the back.

The housing project of Tyrone was started in the summer of 1915 and besides the central plaza and its group of large buildings, 229 apartments have been built to date, and more are in the process of construction. One of the results has been the education of the Mexican laborer to better methods of living. At first it was found that the Mexicans preferred to rent a piece of land at fifty cents per month and build their own

shacks like those of Fig. 12 rather than rent a company house. However, the houses are now taken up by a waiting list and cannot be built fast enough. Moreover, there is a growing demand from the Mexicans for larger and better houses having three or four rooms and bath.

#### GENERAL RESULTS

Tyrone is a spotless town. The sanitary squad cleans the streets, empties garbage and does various other duties to keep the town clean. No charge is made the tenants for this service. Electricity is sold for seven cents per kw.-hour with a minimum of 50 cents per month. Water is furnished for 50 cents per thousand gallons with a minimum of three thousand gallons per month, with an additional cost of 35 cents per thousand gallons for a garden. The management is now planning



FIG. 13.—THE T. S. PARKER HOSPITAL

the diversion of some of the mine water, however, to take care of the latter.

TABLE I  
DESCRIPTION AND NUMBER OF PERMANENT BUILDINGS FOR  
RESIDENCE PURPOSES FULLY COMPLETED AND OCCUPIED

| Jan. 26, 1918      |              |                     |                               |                                 |                              |                                                                         |  |  |  |
|--------------------|--------------|---------------------|-------------------------------|---------------------------------|------------------------------|-------------------------------------------------------------------------|--|--|--|
| Tyrone, New Mexico |              |                     |                               |                                 |                              |                                                                         |  |  |  |
| Type               | Monthly Rent | Number of Buildings | Number of Apartments in Bldg. | Number of Families Accommodated | Number of Rooms in Apartment | Appurtenances                                                           |  |  |  |
| B                  | \$30         | 2                   | Single                        | 2                               | 5                            | Bath, sleeping porch, fireplace (1 with garage)                         |  |  |  |
| X                  | 30           | 4                   | Single                        | 4                               | 5                            | Bath, sleeping porch, fireplace (2 with garage)                         |  |  |  |
| Z                  | 28           | 2                   | Single                        | 2                               | 4                            | Bath, sleeping porch, fireplace                                         |  |  |  |
| O                  | 27           | 3                   | Single                        | 3                               | 5                            | Bath, sleeping porch, fireplace (1 with garage) (1 only with fireplace) |  |  |  |
| U                  | 27           | 3                   | Single                        | 3                               | 4                            | Bath, sleeping porch, fireplace, garage                                 |  |  |  |
| R                  | 25           | 3                   | Single                        | 3                               | 4                            | Bath, no sleeping porch (1 only with fireplace)                         |  |  |  |
| S                  | 25           | 2                   | Single                        | 2                               | 4                            | Bath, no sleeping porch, fireplace                                      |  |  |  |
| SS                 | 24           | 1                   | 2                             | 2                               | 4                            | Bath, no sleeping porch, fireplace                                      |  |  |  |
| V-Lower            | 25           | 1                   | 3                             | 2                               | 5                            | Bath, no sleeping porch, fireplace                                      |  |  |  |
| V-Upper            | 25           | 1                   | 3                             | 2                               | 4                            | Bath, sleeping porch, no fireplace                                      |  |  |  |
| W-Upper            | 23           | 2                   | 2                             | 4                               | 4                            | Bath, sleeping porch, no fireplace                                      |  |  |  |
| W-Lower            | 20           |                     |                               |                                 | 4                            | Bath, no sleeping porch, fireplace                                      |  |  |  |
| P                  | 20           | 2                   | Single                        | 2                               | 3                            | Bath, no sleeping porch, no fireplace                                   |  |  |  |
| 2                  | 20           | 1                   | Single                        | 1                               | 4                            | Bath, no sleeping porch, no fireplace                                   |  |  |  |
| 4                  | 20           | 1                   | Single                        | 1                               | 4                            | Bath, no sleeping porch, no fireplace                                   |  |  |  |
| M                  | 18           | 2                   | 2                             | 4                               | 3                            | Bath, no sleeping porch, no fireplace                                   |  |  |  |
| 3                  | 18           | 1                   | Single                        | 1                               | 3                            | Bath, no sleeping porch, no fireplace, garage                           |  |  |  |
| N                  | 15           | 1                   | 2                             | 2                               | 3                            | No bath, no sleeping porch, no fireplace                                |  |  |  |
| L                  | 14           | 2                   | 2                             | 4                               | 2                            | Bath, no sleeping porch, no fireplace                                   |  |  |  |
| J                  | 12           | 4                   | Single                        | 4                               | 2                            | No bath, no sleeping porch, no fireplace                                |  |  |  |
| K                  | 9            | 6                   | 2                             | 12                              | 3                            | No bath, no sleeping porch, no fireplace                                |  |  |  |
| H                  | 8            | 6                   | 2                             | 12                              | 2                            | No bath, no sleeping porch, no fireplace                                |  |  |  |
| G                  | 6            | 26                  | 6                             | 154                             | 2                            | No bath, no sleeping porch, no fireplace                                |  |  |  |
| 1                  | 27           | 1                   | Single                        | 1                               | 5                            | Bath, no sleeping porch, no fireplace                                   |  |  |  |
| Mine Supt.         | 65           | 1                   | Single                        | 1                               | 6                            | Bath, sleeping porch, fireplace, furnace garage in cellar               |  |  |  |



## The Rôle of Colloids in Chemical Processes\*

IN a recent conversation with a chemist well known throughout the country for his contributions to industrial research, he remarked: "There seem to be fashions and styles in the problems that are brought to us. Sometimes these are mostly of a metallurgical nature, at other times they are inorganic or again organic, while of late, the bulk of the problems that have come before us are in the realm of applied colloid chemistry."

Some of us, too, studied the subject when the memory of Thomas Graham was under a cloud of neglect, or in Germany before Wilhelm Ostwald washed the cloud away to find a field of distinction for his son Wolfgang. Then, as we grow older, we read and forget, and need to have our memory jogged a little to refresh our consciousness of certain important things. With this purpose in view and to bring to the notice of our readers two forthcoming chemical books of importance, we shall extract a few notes on the subject in general and then proceed to add memoranda on applied colloid chemistry from the sources mentioned.

The colloid field has to do with the properties of particles of the approximate diameter of from  $0.1\mu$  ( $0.0001$  millimeter) to the point where crystalloidal solutions begin, which is less than  $10\mu$ . ( $1\mu = 0.001\mu$ ). The smallest particles that can be seen with the ultramicroscope are of about  $5\mu$  diameter. The theoretical H molecule is about  $0.1\mu$ . Then if a human red blood corpuscle were  $25$  ft. in diameter by way of comparison,  $5\mu$  would be quarter the size of a man's finger nail and the H molecule would be hardly more than a speck. Now since it is the surface of these particles which presents their most distinguishing characteristics, let us observe that while one cubic centimeter presents a surface area of  $0.93$  square inches, if it were divided into  $0.1\mu$  cubes we should have  $1,000,000,000,000,000,000$  cubes presenting a surface area of about  $21\frac{1}{2}$  square feet. And if we were to divide it into cubes of  $0.1\mu$ , we should have a million million million cubes presenting a surface of nearly fifteen acres.

We are constantly considering the wandering of particles but sometimes an example is worth while, to show their ways. Here, for instance, is one that is graphic: If we give a man a few grains of lithium chloride and shortly afterward wipe his forehead with a clean platinum wire, the lithium will show in the spectroscope. With the Faraday-Tyndell effect, however, in a solution of  $0.1\mu$  colloidal gold, less than one ten-millionth of a milligram may be detected with the naked eye.

As colloidal particles coalesce, energy seems to be developed. This manifests itself (or "orients" itself as is said in translations, from the German "*orientiert sich*") as lightning in the case of clouds or as heat in the case of metals. Here is a grand field for study and the most delectable playground for speculation.

Protection in the colloidal sense produces a surface skin or pellicle which surrounds each particle and prevents it from coalescing with others. It exercises a

two-fold function: In crystalloidal solutions it provides that reactions take place in detail as it were rather than *en masse*, or, to use a foot-ball simile, it provides for contact in open formation rather than by a flying wedge. After the aggregation of crystalloidal particles into those of colloid dimensions it surrounds these and prevents their union.

Let us note at this point that the radius of molecular attraction is about  $50\mu$  or just within the colloidal field.

*Adsorption* is a phenomenon that goes farther than some of us are disposed to think. For instance, a solution of  $K_2SO_4$  filtered through sand gives a dilute solution of  $H_2SO_4$ . Dissociation has taken place. This fractional dissociation is more observable in electrolytes, for certain salts dissolved in a gel dissociate, and some of their ions diffuse faster than others so that complete separation may take place. Very pretty experiments may be performed in this connection by the use of different indicators in a test tube. Ions of crystalloidal electrolytes receive an electric charge as they are adsorbed by colloidal particles and this results in stabilizing the dispersion. As the iso-electric point is reached, where the charge equals zero, coagulation occurs.

The application of colloid chemistry is so wide that we can give only selected memoranda on the subject.

*Clay and ceramics.* The first historical note we get is in the fifth chapter of Exodus, where it is recorded that the Egyptian taskmasters compelled the children of Israel to make bricks without straw. The use of the straw was not, as is generally supposed, on account of the fibres which served as binders. It was a colloidal substance contained in the straw which caused the particles to deflocculate. Recent patents have been taken out for "Egyptianizing" clay by adding to it tannin, extract of straw, humus and the like. Protective colloids such as glue etc. deflocculate or "free out" clay and make it spread or cover, as in paper coating and kalsomining. The working properties of clay depend largely upon the size of the particles and their state of aggregation. This explains the uselessness of chemical analyses which give only percentage content, if the clay is to be used for certain purposes. Articles moulded of clay and then burned lose their hydrosol condition and become hardened into pottery.

In agriculture it is colloid chemistry that is in large measure the chemistry of practice. The quality of soils has a great deal to do with organic colloids which are found in it, as well as with the size of the soil particles. We have not space even to touch upon this great field.

In electroplating the addition of protective colloids tends to the production of non-crystalline deposits.

*Metallurgy.* Since coarsely crystalline metals are brittle, tending to split along the line of crystal cleavage, various physical or chemical means are employed to obtain a fine hard-grained structure. Among the physical methods are chilling and rolling, while chemical methods involve the removal of undesirable constituents (as in the conversion of pig iron to steel) or the addition of desirable constituents (as in case-hardening or the manufacture of alloy steels). For instance, it is shown that the predominant effect of vanadium in steel is to decrease the size of the ferrite grains and to make the material harder; it renders the ordinary structure due to pearlite fine and homogeneous. While the question is one of great complexity, many facts at present

\*EDITOR'S NOTE. We have been permitted to look over the proof-sheets of Mr. Jerome Alexander's forthcoming book on "Colloid Chemistry" as well as his contribution of "The Practical Application of Colloid Chemical Principles" to the new edition of Rogers' "Industrial Chemistry," and we believe a few notes from them to be timely.

available seem to indicate that one of the causes favoring the fine-grained structure in such instances is the inhibition of crystallization by substances colloiddally dissolved in the molten mass. Thus, part of the carbon in iron and steel is graphitic, and as graphite is slightly soluble in iron, under proper conditions some of it will assume a colloidal form and act as a protector.

An interesting research note follows: Moissan said that the addition of a little platinum to metallic mercury caused the latter to emulsify in water. Upon making the experiment, according to Moissan, Mr. Jerome Alexander noticed that the supernatant liquid remained turbid. On standing, examination of the fluid in his ultra-microscope revealed the presence of colloidal metallic particles in active motion.

In dyeing, colloid chemistry throws light upon points which were heretofore obscure. For instance, it is possible to obtain more level colors in old dye liquors than in fresh ones, and the explanation proposed is that colloiddally dissolved substances are responsible for the phenomenon in that they exercise a restraining action upon the adsorption of color. They slow down the process. The level dyeing facilitated by the addition of Glauber's salt may be due to its action as an electrolyte producing a partial coagulation of the dye-stuff so that its particles, thereby made larger, are adsorbed more slowly and evenly.

**Soap.** The colloidal nature of soap solutions is indicated by their turbidity and their gelatinization. The detergent action of soap is consequent upon its deflocculating effect as was shown in the Cantor Lecture of H. Jackson (*Journal Soc. Arts*, 55, 1101, et seq.) who examined microscopically the supernatant fluid from washing a dirty cloth and found in it countless particles in a state of oscillatory motion ("pedesis"). When an individual fibre was bathed in soap solution, the dirt particles gradually loosened and began to oscillate, while upon substituting salt solution for the soap, the particles flocculated and the motion ceased. Mr. Alexander observes that an ultra-microscopic examination of the detergent effect produced by soap should prove of interest. The subject has long needed explanation and no one is better qualified to blaze the trail. The answer certainly seems to lie over in this field.

In regard to transparent soaps, there is a memorandum of an original experiment by the author which has a bearing upon metallurgy. According to W. D. Richardson, a transparent soap is a supercooled or supersaturated solution, having crystalline tendencies and exhibiting colloidal properties. Bearing in mind that the salts of the higher fatty acids dissolve in water as colloids and in alcohol as crystalloids, and also that alcohol or equivalent solvents such as glycerol, sugar etc. are used in transparent soap, it seems probable that the crystals which frequently form in it are due to the slow separation of such part of the soap as is in crystalloid solution. The crystalloid phase of soap is apparently governed by the same factors as those which Tamman pointed out as governing the crystallization of supercooled solutions: first, the specific power of crystallization; second, the speed of crystallization; and third, the viscosity. It seemed to Mr. Alexander, therefore, that an important factor in determining the transparency of transparent soap would be the speed of cooling, and he made some experiments

along this line. A piece of commercial transparent soap was melted and cast into two cups, one of which was quickly chilled in ice, while the other was allowed to cool slowly by immersion in hot water. The quickly cooled piece was transparent while the other was practically opaque and showed on ultra-microscopic examination much larger ultra-microns than the transparent piece. After standing three or four months, the quickly cooled soap was still transparent to the naked eye, whereas large opaque spots could be seen in the slowly cooled piece. In the ultra-microscope the former appeared as before, whereas the latter showed large and perfectly resolvable crystals in a clear matrix.

These experiments give us an inkling as to what occurs during the "heat treatment" and tempering of metals, and it is to be hoped that some technique may be devised that will give us even a clearer insight than does etching into the changes that occur in metals in heat treatment, use, age, and even "disease" (tin for example).

**Milk.** This product contains salts and sugar in crystalloid solution, casein and lactalbumen in colloidal dispersion and milk fat in suspension. Upon reaching the stomach the casein of cow's milk coagulates into great hunks; that of mother's milk into fine flakes; and that of mare's milk remains almost fluid. That cow's milk is indigestible by many persons and may not be taken with impunity by infants is well known. The addition of protective colloids to cow's milk stabilizes it and makes it act more like mother's milk when treated with acid and rennin. If sufficient protective colloid be added the coagulate may be kept in a very fine state of subdivision. Gelatin and gum arabic are used for this purpose. Sodium citrate also acts as a protective colloid.

Ice cream, as those who make it know, if made without eggs, gelatin or some similar colloidal ingredient, is gritty, grainy or sandy, or it will soon become so upon standing, whereas ice cream made with small quantities of protective colloids has the rich, mellow, velvety texture so much desired. The colloid acts as an inhibitor of crystallization and as a preserver of texture. It is also very beneficial from a digestive point of view. Nevertheless, some official food chemists of the type that use publicity bureaus for their laboratories and newspaper columns for their literature have been known to declare the expensive and desirable gelatin to be nothing but "filler," and have cautioned the public against it.

**Tanning.** The skins of animals constitute an organized colloid jelly formed of bundles of fine fibrils, about 1 $\mu$  in diameter, bound together by a cementing material of similar chemical composition which is largely removed by liming and other treatment which precedes the tanning proper. When the swollen hide is placed in the acid tanning solution, the tannin is powerfully adsorbed by the fibre and combines with it to form leather. The positively charged hide and the negatively charged tannin naturally coagulate each other. If the tar liquor is alkaline, both the tannin and hide become negatively charged and no tanning occurs. Gelatin, when neutral and free from electrolytes, does not precipitate pure tannin, but in an acid solution it takes a positive charge and is tanned. The tanning process may be aided electrically by giving the



hide a suitable potential, positive in the case of tannin and negative in the case of chromium compounds.

**Rubber.** This product is made by coagulating the milky juice or latex of various plants. Rubber latices are emulsions stabilized by protective colloids (proteins or peptones) and the nature of the coagulant depends upon the nature of the protector. Vulcanization consists of the combination of sulphur with rubber. At first the sulphur is adsorbed; then by heating, part of it enters into a close combination, probably into a true chemical combination.

**Photography.** The photographic plate owes its sensitiveness to an emulsion of colloidal silver halides stabilized by a protective colloid (gelatin, albumen or collodion). The degree of dispersion is controlled by the condition of precipitation of the silver salt and the subsequent treatment of the emulsion. The latent image formed upon the exposure of the plate to light is probably an adsorption compound between colloidal silver and silver halides. This is an interesting definition of silver sub-halides and gives us a chance to think of bromine as mono-valent in this connection which is comforting to old-fashioned chemists who are likely to grow restive under the consideration of polyvalent halogens. It seems, under such conditions, as though the halogens had become addicted to evil practices.

**Cement, Mortar and Plaster.** When freshly mixed, mortar and cement contain colloidal sols or gels which gradually coagulate and set or bind the crystalline element of the plaster into a coherent whole. The setting of plaster of Paris has for many years been slowed down by colloidal retarders. Observations were made by preparing microscopic slides with equal parts of plaster of Paris and water to which had been added varying proportions of gelatin with the following results:

| Per Cent Gelatin | Time to Set in Minutes | Microscopic Appearance of Slide                                                                                                 |
|------------------|------------------------|---------------------------------------------------------------------------------------------------------------------------------|
| 0.00             | 40                     | Characteristic interlacing crystals of calcium sulphate.                                                                        |
| 0.01             | 50                     | No true crystals except in a few spots where some colloid-free solution had diffused out. Elsewhere aborted spherulic crystals. |
| 0.10             | 260                    | No true crystals.                                                                                                               |
| 0.25             | 510                    | No true crystals.                                                                                                               |
| 0.50             | 960                    | No true crystals.                                                                                                               |
| 1.00             | Not set in 48 hours    | No true crystals.                                                                                                               |
| 2.00             | Not set in 48 hours    | No true crystals.                                                                                                               |

In chemical analysis the presence of colloids may lead to grave errors, so that the chemist should destroy them by ignition or overcome their effects by coagulation. Reversible colloids, often referred to as "organic matter," may prevent the formation of precipitates, just as tartaric acid or tartrates prevent the precipitation of alumina, chromic oxide or ferric oxide. They may also prevent the satisfactory filtration of the precipitate formed or they may render precipitates difficult to wash and purify. As an example, three solutions of lead acetate were taken. To the first was added HCl which yielded a heavy, coagulated precipitate. To the second was added NaCl (a less highly ionized precipitant) which yielded a colloidal precipitate of lead chloride. To the third was added first a little glue solution and then sodium chloride; in this no visible precipitate was formed.

**Foods.** Here is a sentence that in these days of domestic economy and Kitchen Kemistry should be learned by heart and repeated often: It is a serious

error to judge foods upon the basis of a bald chemical or calorific analysis; fat, protein, carbohydrate and calories are not alone the criteria of food values; the physical condition of food largely governs its usefulness to the organism. For instance, light bread is more wholesome than heavy bread because the former presents an enormous surface to the digestive juices. In biblical times, unleavened bread was eaten only in time of stress. Again, the meats of young animals differ from those of old ones in that the latter are formed of tissues partially dehydrated by age. Notwithstanding all our talk, we have not yet reached a proper appreciation of the great art of cooking.

#### BODY AND PLANT COLLOIDS

**Physiology and Pathology.** The changes which occur in almost all physiological processes are produced at comparatively low temperatures and in the presence of very dilute reagents. The living organism disintegrates proteins, oxidizes carbohydrates and with the same apparent ease synthesizes substances of great complexity. The body and plant colloids (biocolloids) consist of carbohydrates (starch, cellulose, glycogen), proteins (plant and animal albumens) and lipoids (lecithins, cholesterolin, fats and oils). Each tissue has a normal turgor or state of swelling which is greatly influenced by acids, alkalies and salts. The swelling and shrinking of tissues, together with their selective adsorption and the differential diffusion of solutions through them, account for or accompany many physiological phenomena, both normal and pathological.

Thus, fibrin and gelatin swell much more in very dilute acid than in distilled water, but the swelling is depressed by salts. Fibrin is so sensitive that it swells in the presence of traces of acid quite undetectable by ordinary indicators such as litmus; in fact, fibrin itself is an extremely sensitive indicator, and can by its swelling actually distinguish distilled water from the still purer conductivity water.

Local accumulation of acid in the organism may cause swelling (edema); for example insect stings, which may be imitated by stinging gelatin with a needle dipped in acid. If acid accumulates in an organ within a rigid capsule (eyes or kidneys) the swelling tends to establish a vicious circle (glaucoma, nephritis) by compressing the blood vessels and cutting down the alkaline blood stream, which is unable to wash out the acids (mainly CO<sub>2</sub>) formed by living protoplasm.

If the oxidation processes of the body are normal, the hydrogen in foods is oxidized mainly to water and the carbon mainly to carbonic acid, a gaseous acid which is exhaled without demanding protein or fixed alkali of the organism for its elimination. In the case of pathological oxidation, however, other acids are formed and a condition called "acidosis" may arise. This is in reality a diminished alkalinity, recognizable by the fact that an abnormally large quantity of bicarbonate of soda is needed to render the urine alkaline. These acids may cause not only disturbances of the body colloids, but disease and even death. In fact, throughout life there is a gradual syneresis of the biocolloids, accompanied by visible shrinking and loss of water as is indicated by the comparison of the chubby hand of a child with that of an old man. In plants an analogous process occurs in lignification.



## Potash in Nebraska

By J. M. LLITERAS

IN 1912, when two students from the University of Nebraska filed claims on Jesse Lake with the purpose in view of extracting potash salts, no one thought they were starting an industry which a few years later was to be in the forefront in the State of Nebraska, and the industry which the farmers of the United States were to depend upon for their supply of potash fertilizer. These students, Show and Modesitt, tested various lakes in the "Sand Hills" of Western Nebraska and arrived at the conclusion that Jesse Lake would be the most profitable to them. The decision was a wise one, for there has not yet been found another lake equal to it. The Potash Products Co., and its successor, the Potash Reduction Co., has been drawing on Jesse Lake steadily for about five years, and it shows few if any signs of exhaustion.

There were many untouched lakes in this region, however, and today the present field from which the

shows conclusively that it is but a matter of time until the lake will fail to "come back." This will happen when the supply of salts to this particular lake has been exhausted. The reader may ask why it is that Jesse Lake, which was tapped first and has been drawn upon heaviest, has not given out. The answer is that the supply which is feeding this particular lake must be enormous, although it is not inexhaustible.

The loading stations for the Nebraska potash industry are at Antioch, Hoffland and Lakeside, all situated on the main line of the Chicago, Burlington and Quincy Railroad, near the division point, Alliance. Since the small lakes are scattered over a large area, it is necessary to pipe the brine to a central evaporating station. Most of the brine used today by the various companies is pumped from wells, the depth of which varies from 12 to 30 ft., depending entirely upon the nature of the lake in which they are placed. These wells consist of pipe,  $\frac{3}{4}$  to 2 in. in diameter, to the end of which is attached a well-point 18 in. to 6 ft. long. This point is imbedded in gravel, poured into the well

at the time it is bored and before the casing is withdrawn. The wells are spaced from 10 to 20 ft. apart, this distance again being governed by local conditions in that particular lake. The wells connect to a sub-header, while the various sub-headers in the system join the main header which is also the pump suction. At present very little is being done toward primary concentration of the brine at the place of pumping, so the brine as taken out of the lake is pumped to the evaporating plant through 4- or 6-in. pipe lines. Six-inch wood pipe is now being used exclusively on account of the scarcity and prohibitive cost of wrought iron pipe. In some instances

the wells in lakes have been pumped several weeks after the bed of the lake was dry. At other times fresh water was pumped in to cover the surface for two reasons: first, to keep the wells sealed so as to prevent air leakage into the main pipe system; and second, to allow this clear water to percolate through the sand bed, collecting in its travel any crystals of soluble salts with which it may come in contact before reaching the well-point.

Evaporation practice used in the Nebraska potash industry is nothing new, most of the companies using Swenson or Devine Evaporators. The Swenson system of evaporation may be readily understood by following the accompanying diagram, Fig. 1.

The potash-bearing water as it comes from the reservoir first enters the condenser where it liquefies the vapors from the third effect, producing in the latter a vacuum, the amount of which is governed largely by the

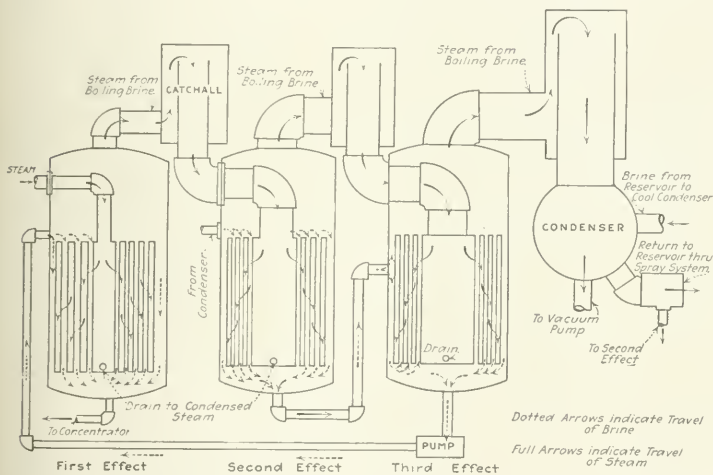


FIG. 1.—SWENSON SYSTEM OF EVAPORATION

various companies are pumping extends over an area of about 330 square miles. Potash has also been found in other lakes outside of this field; possibly the brine waters are scattered over a total area of about 600 square miles.

It has been definitely proved by the continuous pumping of certain lakes that the potash supply of Western Nebraska is not inexhaustible.<sup>1</sup> In fact, the water in the majority of the lakes lowers in density after being pumped for a certain length of time, there being a specific instance where a lake first delivered brine with a density of 10 deg. Bé., while after five months' pumping the density of the brine coming from the same wells was only 2 deg. Bé. Another peculiarity about these lakes is that if they are allowed to "rest" for a certain length of time, the density will increase and in rare instances assume the original specific gravity, only to decrease again after a second pumping. This

<sup>1</sup>See communication from W. A. Norris on this subject in *Metalurgical & Chemical Engineering*, Mar. 15, 1918.

<sup>2</sup>See a description of "The Nebraska Potash Industry," *Metalurgical & Chemical Engineering*, Dec. 15, 1917.

temperature of the boiling brine contained in that cell. During its travel through the condenser the dilute solution naturally becomes hot, and the necessary fraction is taken through the pipe line marked "To second effect." The balance and greater portion of the water is returned to the reservoir through a spray system. The purpose of spraying this water is first to take advantage of the evaporation that will take place when the hot brine is sprayed into the cooler atmosphere, and, second, to keep the temperature of the liquid in the reservoir as low as possible. Brine enters the second effect at about the same density that it comes from the lake; there it is boiled under a vacuum of from 1 to 10 in. and a temperature of from 180 to 200 deg. F. by the heat given up by the vapors formed in the first effect. From the second effect the brine goes to the third effect where it is boiled under a vacuum of 15 to 24 in. and a temperature of from 130 to 150 deg. F. by the heat given up by the vapors formed in the second effect. Finally, from the third effect the concentrated liquor is pumped to the first effect, where it is boiler under a pressure of 4 to 12 pounds and at a temperature of 220 to 240 deg. F. by live steam from the boiler house. The process is a continuous one and is so regulated that the density of the brine in the first effect is raised to 20 deg. Bé. when the contents are pumped into the "concentrator" for further evaporation.

Each cell of the evaporator consists of a steel shell inside of which is a "basket" composed of many 2-in. tubes, the brine being around the basket and the steam inside it. In no case do the brine and the steam come in actual contact with each other. The concentrator, which is not shown in Fig. 1, is similar to a cell of the triple effect evaporator except that it is provided with a circulating pump to keep the brine agitated at all times. This is necessary in order to prevent any separated salts from settling to the bottom, which would invariably happen if the liquid were not kept in constant motion. Live steam is used for heating the solution in the concentrator. The density of the brine is here carried to between 30 and 40 deg. Bé., varying inversely with the amount of soda contained.

The efficiency of the above method of evaporation is constantly being improved by such expedients as placing a heater between the second and third effects, by using the exhaust steam from the concentrator for further boiling and by several other small improvements that will increase the density of the brine in its travel through the system.

Drying the salts has been a hard problem in this region, much money having been spent on various types of dryers while only one has proved at all satisfactory. We are now expectantly awaiting results obtained in a drier under construction by the Western Potash Works at Antioch, which is entirely different from anything ever tried before. The successful dryer in universal use consists of a cylindrical steel shell 30 to 45 ft. long, and 4 to 6 ft. in diameter. The saturated brine as delivered from the concentrator is sprayed into the cylinder at the upper end, and travels toward the fire end. The precipitated salts are thus subjected to the highest heat just before the brine is discharged from the dryer. The shell is provided with inner baffles and rollers to keep the dried salts from adhering to it.

This type of dryer will deliver salts with a moisture content as low as 0.5 per cent, although the most economical point has been found to be around 3 per cent.

The cool end of the dryer is connected to a dust chamber through which the dust and gases pass. Baffles catch the entrained dust quite successfully, and tests of the gases at the top of the stack show very little if any potash when the dryer is running under normal conditions.

Nebraska is now producing about 450 tons of salts daily, with an average potash content of 25 per cent. This production is expected to be further increased in the near future when the latest plant to begin operations comes into its own, and when two others which are now under construction begin operations.

Our potash industry has had its opportunity due to lack of German products. It developed during war times and naturally had to pay war prices for all materials. It had to educate its own labor and make living conditions in the Sand Hills such that it would be possible for families to settle there. It had an uphill fight all the way to prove that it was an essential industry and to get preference on all necessary materials.

A great question in the minds of many people today is whether Nebraska potash can compete with the German product after the war? However, this is not the question that is bothering the people financially interested in the industry. They are more interested in the excess profits section of the revenue bill now in Congress. If the bill does not allow the potash plants to write off their investments in the plants before heavy taxes shall accrue, it will greatly retard the industry; while if they are allowed the amortization of the plants first it will mean its salvation, and would greatly stimulate and promote the somewhat hampered production. Favorable action now would greatly help this new-born American industry to make the United States self-supporting after the war and make us independent of German potash.

Antioch, Nebraska.

### Importation of Copper Ore

The ruling of the War Trade Board (No. 211) affecting the importation of copper ore has been so far modified by a new ruling (W. T. B. R. 249) as to permit the importation of copper concentrates containing 50 per cent or over of copper from non-enemy countries, instead of 60 per cent or over as in the former ruling. The previous restriction prohibiting the importation of ore, except from Cuba, Canada or Mexico, and of copper concentrates containing less than 50 per cent of copper, except from the above countries, remains in force. There is no restriction upon the importation from any non-enemy country of copper matte, blister copper, or copper concentrates containing 50 per cent or more of copper.

### Synthetic Phenol

Attention is called to an error which occurred in the make-up of Mr. Peterkin's article on this subject in our issue for September 1. Titles of Charts I and II were inadvertently reversed.

\*See "Potash, I. W. W. and the Fuel Administration," *Metallurgical & Chemical Engineering*, Nov. 15, 1917.

# Aluminium and Its Light Alloys—V

**Duralumin Is the Most Remarkable Light Alloy of Aluminium, Resisting Corrosion and Possessing Important Physical Properties—Four Types of Deterioration of Aluminium Alloys**

By PAUL D. MERICA

## DURALUMIN<sup>1</sup>

THE most remarkable light alloy of aluminium is undoubtedly duralumin, the behavior and properties of which were discovered by Wilm (474) during his investigation during the years from 1903 to 1911. The remarkable feature about it is that, alone among light aluminium alloys, its mechanical properties may be vastly improved by heat treatment.

The composition of this alloy varies somewhat; on the continent the following range of compositions is used:

|                 | Per Cent |
|-----------------|----------|
| Copper .....    | 3.5—5.5  |
| Magnesium ..... | 0.5      |
| Manganese ..... | 0.5—0.8  |
| Aluminium ..... | balance  |

It is thus an alloy which can readily be rolled or forged; indeed it is always used in this condition, since the development of its highest physical properties involves the application of mechanical work to it.

The electrical resistivity of annealed duralumin is 3.43 microhm-cm.; in the heat-treated condition, however, in which it is always used, the resistivity is much higher, being 4.73 microhm-cm. In this condition it has approximately 35 per cent of the volume-conductivity of copper.

The density of duralumin varies from 2.75 to 2.84; its melting point is about 650 deg. C.

When this alloy is heated for a few minutes at temperatures from 400 to 520 deg. C. and quenched in water the hardness is very little increased over that which would be obtained by slowly cooling the same alloy. But upon aging the quenched alloy for several days at ordinary temperature both the hardness and the ductility are increased from 15 to 50 per cent, depending on the composition of the alloy and the quenching temperature. Thus an alloy showed the following changes of properties:

|  | After rolling,<br>before<br>hardening. | After hardening,<br>quenching<br>and aging. |
|--|----------------------------------------|---------------------------------------------|
|--|----------------------------------------|---------------------------------------------|

|                                       |        |        |
|---------------------------------------|--------|--------|
| Tensile strength, lb. per sq.in. .... | 37,000 | 58,000 |
| Elongation, per cent ....             | 17     | 23     |

The change of hardness during aging is shown in Fig. 22.

After hardening this alloy by quenching and aging, it may be still further hardened by cold work, at the cost, of course, of ductility. The curves, Fig. 23, show the increase of tensile strength and decrease of ductility that occur when both annealed and hardened duralumin are cold-worked.

The hardness produced by hardening is of course

TABLE XVIII.  
TENSILE PROPERTIES OF DURENER DURALUMIN

| Cohn (473, 476)           |                                   |                                        |                                          |                                   |
|---------------------------|-----------------------------------|----------------------------------------|------------------------------------------|-----------------------------------|
| Treatment                 | Yield Point,<br>lb. per<br>Sq.In. | Tensile Strength,<br>lb. per<br>Sq.In. | Elonga-<br>tion<br>in 2<br>In., Per Cent | Reduction<br>of Area,<br>Per Cent |
| Alloy 11, Density 2.75    |                                   |                                        |                                          |                                   |
| Soft—7 mm. ....           | 27,000                            | 51,200                                 | 25.0                                     | 34.0                              |
| Rollled to 6 mm. ....     | .....                             | 54,000                                 | 10.0                                     | 22.0                              |
| Rollled to 5 mm. ....     | .....                             | 59,800                                 | 6.3                                      | 18.0                              |
| Rollled to 4 mm. ....     | .....                             | 61,900                                 | 5.0                                      | 13.0                              |
| Rollled to 3 mm. ....     | .....                             | 64,800                                 | 5.0                                      | 14.0                              |
| Rollled to 2 mm. ....     | .....                             | 67,500                                 | 4.0                                      | 12.0                              |
| Alloy 681-B               |                                   |                                        |                                          |                                   |
| Soft—7 mm. ....           | 40,000                            | 62,800                                 | 17.6                                     | 21.7                              |
| Rollled to 6 mm. ....     | 67,000                            | 71,100                                 | 8.0                                      | 16.3                              |
| Rollled to 5 mm. ....     | .....                             | 75,000                                 | 5.3                                      | 12.7                              |
| Rollled to 4 mm. ....     | .....                             | 78,300                                 | 4.0                                      | 9.7                               |
| Rollled to 3 mm. ....     | .....                             | 80,500                                 | 3.4                                      | 7.3                               |
| Rollled to 2 mm. ....     | .....                             | 83,200                                 | 2.5                                      | 6.6                               |
| Alloy 681-D, Density 2.83 |                                   |                                        |                                          |                                   |
| Soft—7 mm. ....           | 36,900                            | 65,300                                 | 17.5                                     | 21.0                              |
| Rollled to 6 mm. ....     | 58,600                            | 74,200                                 | 8.6                                      | 18.0                              |
| Rollled to 5 mm. ....     | 64,200                            | 78,500                                 | 6.6                                      | 15.0                              |
| Rollled to 4 mm. ....     | .....                             | .....                                  | .....                                    | .....                             |
| Rollled to 3 mm. ....     | 75,400                            | 84,000                                 | 4.6                                      | 11.0                              |
| Rollled to 2 mm. ....     | 77,000                            | 88,300                                 | 3.0                                      | 11.0                              |
| Alloy 681-A, Density 2.79 |                                   |                                        |                                          |                                   |
| Soft—7 mm. ....           | 35,100                            | 59,500                                 | 21.1                                     | 29.5                              |
| Rollled to 6 mm. ....     | 65,900                            | 67,700                                 | 9.0                                      | 21.5                              |
| Rollled to 5 mm. ....     | .....                             | .....                                  | .....                                    | .....                             |
| Rollled to 4 mm. ....     | 69,200                            | 75,000                                 | 5.0                                      | 14.5                              |
| Rollled to 3 mm. ....     | .....                             | .....                                  | .....                                    | .....                             |
| Rollled to 2 mm. ....     | 75,400                            | 79,600                                 | 4.0                                      | 13.2                              |
| Alloy 681-C.              |                                   |                                        |                                          |                                   |
| Soft—7 mm. ....           | 40,600                            | 64,200                                 | 17.6                                     | 22.0                              |
| Rollled to 6 mm. ....     | 67,800                            | 73,200                                 | 7.4                                      | 14.5                              |
| Rollled to 5 mm. ....     | .....                             | 76,800                                 | 5.2                                      | 12.5                              |
| Rollled to 4 mm. ....     | .....                             | 80,000                                 | 4.5                                      | 8.7                               |
| Rollled to 3 mm. ....     | .....                             | 82,500                                 | 3.5                                      | 8.0                               |
| Rollled to 2 mm. ....     | .....                             | 85,800                                 | 3.1                                      | 6.3                               |

lost upon annealing at rather low temperatures. The curves of Fig. 24 show the effect of annealing at different temperatures followed by air-cooling, upon the hardness and ductility of a hardened duralumin. It is noticed that duralumin hardens slightly even when cooled in air.

Duralumin loses its hardness at higher temperatures. Fig. 25 shows the effect of higher temperatures upon the hardness of this alloy.

Table XIX gives the results of a number of tests of commercial duralumin from the Dürer Metallwerke A. G.

TABLE XIX—EFFECT OF 14 MONTHS' IMMERSION OF DURALUMIN IN DIFFERENT SOLUTIONS. COHN (471, 473)

| Solution Concentration         |                                    | Decrease in Thickness. | Description of Sample                                           |
|--------------------------------|------------------------------------|------------------------|-----------------------------------------------------------------|
| HCl                            | 1/10 u                             | 0.28                   | Samples were all attacked with pits and holes.                  |
|                                | 1/5 u                              | 0.25                   |                                                                 |
|                                | 1 u                                | 2.05                   |                                                                 |
| HNO <sub>3</sub>               | 1/10 u                             | 1.75                   | Attack uniform.                                                 |
|                                | 1/5 u                              | 0.45                   | Attack uniform.                                                 |
|                                | 1 u                                | 0.10                   | Attack uniform.                                                 |
| Acetic                         | 50%                                | 0.03 to 0.05           | Attack uniform except where at surface exposed to acid and air. |
|                                | 1/10 u                             | 0.03 to 0.10           |                                                                 |
|                                | 1/5 u                              | 0.20 to 0.25           | Attack uniform.                                                 |
| H <sub>2</sub> SO <sub>4</sub> | 1/10 u                             | 0.38                   | Attack uniform.                                                 |
|                                | 1/5 u                              | 0.85                   |                                                                 |
|                                | 50%                                | 0.13 to 0.35           |                                                                 |
| NH <sub>4</sub> OH             | Concentrated in hood of laboratory | 0.11 to 0.13           | Gray layer, attack uniform.                                     |
|                                | Acid vapors                        | 0.5 to 0.75            | Uniform attack                                                  |
|                                | HgCl <sub>2</sub> 10 g             | 0.00                   | Material attacked but not brittle. No action.                   |

<sup>1</sup>Most of the data in the paragraphs on duralumin have been taken from articles by Cohn (471-473, 476).



Duralumin<sup>1</sup> when heat treated and cold worked to give about 6 per cent elongation in 2 in. corresponding to a yield point above 35,000 lb. per sq.in., will withstand unlimited alternations of stress between 0 and 20,000 lb. per sq.in. tension.

**Corrosion.** Duralumin in the hardened condition is remarkably resistant to corrosion, considering that it contains much copper which is recognized to be usually a harmful constituent of an aluminium alloy from the standpoint of corrosion. This fact is particularly important in view of the use of the alloy for construction

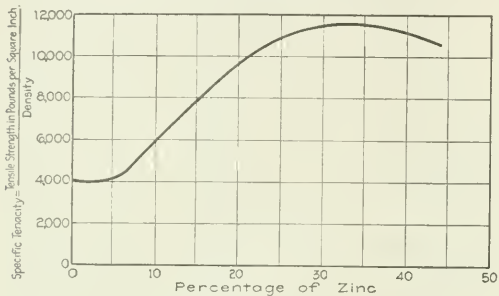


FIG. 22

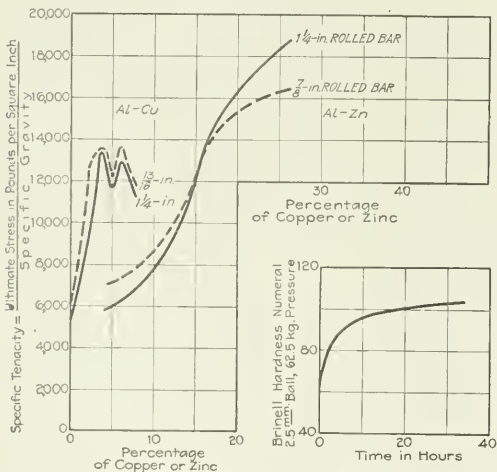


FIG. 23

FIG. 24

Fig. 22—Specific Tenacity of Sand-Cast Zinc-Aluminum Alloys (Rosenhain and Archbutt, 438).

Fig. 23—Comparison of Specific Tenacities of Rolled Al-Zn and Al-Cu Alloys (Rosenhain and Archbutt, 438).

Fig. 24—Increase of Hardness of Duralumin Upon Ageing After Quenching (Cohn, 471, 473).

where it will be subject to weathering and corrosion.

The Dürer Metallwerke A. G. have made extensive investigation of this feature. Sheets 2.35 mm. thick were immersed for 14 months in several solutions and the decrease in thickness measured as well as appearance observed after that time. Table XIX gives the principal results of these tests.

A mixture of concentrated  $H_2SO_4$  and  $HNO_3$  scarcely attacks duralumin, nor does concentrated  $H_2SO_4$  containing some dissolved  $K_2Cr_2O_7$ ; the latter is recommended as a cleansing solution for duralumin vessels.

<sup>1</sup>Private communication from The Aluminum Castings Company, through Prof. Jeffries.

Some tests made at the shipbuilding docks of Vickers Ltd., Barrow-in-Furness, indicate that duralumin in the hardened condition resists the action of sea-water very well indeed. Four strips, one foot square, were hung on the ways such that at low tide they were above the water level, at high tide, immersed. After six months the losses in weight and thickness were as follows:

| No.    | Loss in Weight<br>Gram per Sq.Cm. | Loss in Thickness<br>in Cm. |
|--------|-----------------------------------|-----------------------------|
| 1..... | 0.00105                           | 0.00038                     |
| 2..... | 0.00107                           | 0.00039                     |
| 3..... | 0.00045                           | 0.00016                     |
| 4..... | 0.00062                           | 0.00023                     |

The Luftschiffbau-Zeppelin-Gesellschaft exposed angles and U-profiles of duralumin, copper, iron, aluminium alloys, pure aluminium, and elektron to the action of sea air and spray on a light-ship in the North Sea for three months. These sections were also riveted and screwed together. Duralumin resisted these conditions

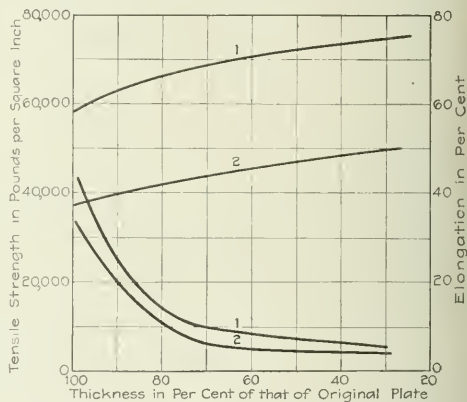


Fig. 25—Increase of Hardness of Duralumin by Cold Working (Cohn, 471, 473). 1. Tensile Strength and Elongation of Hardened Duralumin. 2. Same for Rolled But Not Hardened

better than any of the other materials (Cohn—*loc. cit.*), and showed practically no oxidation.

Investigation has also been made of the alteration in mechanical properties of duralumin brought about by exposure to corrosion. It is known that some alloys of aluminium and aluminium itself often suffer deterioration in this manner. The Dürer-Metallwerke A. G. exposed bars and wire of different sizes of duralumin on the roof of one of their buildings for two and one-half years. Samples were tested from time to time and within that period no evidence of any alteration in hardness or ductility was shown. Evidently the properties of this material acquired by hardening are quite stable.

There are described below some tests on the stability of aluminium alloys, including duralumin when tested in a corroding medium.

From the foregoing paragraphs it is seen that duralumin has been subjected to rather extensive and severe tests covering its properties and their stability under different conditions. It is apparently a most excellent material for construction purposes, for the production of structural members, for forgings and for tubes, bars and wire.

It is possible to weld duralumin in the same manner as pure aluminium. The joint is not as strong as the

TABLE—XX TENSILE PROPERTIES OF DURALUMIN

| Form                  | Tensile Test                      |                              |                               |
|-----------------------|-----------------------------------|------------------------------|-------------------------------|
|                       | Tensile Strength, Lb. per Sq. In. | Yield Point, lb. per Sq. In. | Elongation, in 2 in. Per Cent |
| Sheet.....            | 55,000                            | 25,000                       | 15                            |
|                       | 50,000                            | 23,000                       | 20                            |
| Tubes.....            | 55,000                            | 25,000                       | 12                            |
|                       | 50,000                            | 23,000                       | 20                            |
| Bars:                 |                                   |                              |                               |
| 1/2 to 1 in. ....     | 55,000                            | 25,000                       | 15                            |
| 1 to 2 in. ....       | 50,000                            | 23,000                       | 15                            |
| 2 in. and above ..... | 45,000                            | 20,000                       | 15                            |

original material, however, since the heat of welding destroys the properties produced therein by hardening. By cooling the joint rapidly after welding some improvement may be made. For the present therefore construction work with duralumin may best be done by riveting or other mechanical forms of jointing work.

In table XX are given the physical properties which may usually be obtained for duralumin in different forms.

## MISCELLANEOUS ALLOYS

In the foregoing paragraphs have been described those alloys which have been used commercially to some extent. There are described in the patent and periodical literature almost as many light aluminium alloys as there have been investigators interested in them, and it would be useless to attempt to enumerate all of them. In table XXI however is given a list of many of them, together with whatever information is known about them. The numerical values given in this table are merely those published and are not guaranteed.

A list of patents covering light aluminium alloys, complete for the United States and incomplete for other countries, is given in Table XXII.

The alloys of magnalium have been studied by Mach (Krause, p. 107).

The alloys of aluminium, zinc and magnesium have been studied by Murmann (Krause, p. 108).

D. R. Patent 231,060, 1909, describes the properties of alloys of aluminium, copper, manganese and silver  
D. R. Patent 242,313, 1911, describes the properties of alloys of aluminium with cobalt and tungsten.

Rübel (Krause, p. 129) describes the properties of alloys of aluminium with phosphorus.

Borchers (Krause, p. 130) describes the properties of aluminium to which cerium has been added. This metal is a good deoxidizer and fluxes for aluminium, and is said to reduce its content of silicon.

Uyeno (Krause, p. 132) describes alloys of aluminium with mercury and zinc which are used to generate hydrogen (with hot water) for balloons.

## X. PHYSICAL PROPERTIES OF LIGHT ALLOYS

Besides the usual mechanical properties of alloys, the engineer (particularly the aircraft engineer) is interested in (1) the effect of temperature on the mechanical properties of the light alloys, and (2) the thermal conductivity of casting alloys (motor pistons).

Besides the tests by Rosenhain and Archbutt on aluminium-zinc alloys (438), some of which are described above, and those on duralumin by Cohn (476), (described above), no results of tensile tests of light alloys at high temperature have been published. In general, however, a light alloy to withstand high temperatures should be made with a metal or metals of high melting point, such as iron, manganese, or nickel. An alloy contain-

TABLE XXI—MISCELLANEOUS LIGHT ALLOYS

| Name of Alloy      | Per Cent Composition              |       |        |       |               |                   | Density,<br>Gr. per Cu.Cm. | Use or Condition in Which<br>Used | References | Tensile Properties                         |                                       |                            | Elongation,<br>Per Cent |
|--------------------|-----------------------------------|-------|--------|-------|---------------|-------------------|----------------------------|-----------------------------------|------------|--------------------------------------------|---------------------------------------|----------------------------|-------------------------|
|                    | Al                                | Cu    | Zn     | Mg    | Mn            | Ni                |                            |                                   |            | Tensile<br>Strength,<br>Lb. per<br>Sq. In. | Yield<br>Point,<br>Lb. per<br>Sq. In. | Reduc-<br>tion<br>of Area, |                         |
| Zincum             | 60 (7)                            | ..... | 40 (7) | ..... | .....         | .....             | 2.95                       | Cast for instrument parts.        | Law (271)  | 24,000                                     | .....                                 | .....                      | .....                   |
| Aluminum           | 85 (7)                            | ..... | 15 (7) | ..... | .....         | .....             | 2.95                       | Cast for instrument parts.        | Law (271)  | 11,000                                     | .....                                 | .....                      | .....                   |
| Magnesium X        | .....                             | 1.76  | .....  | 1.60  | .....         | 1.16              | .....                      | High strength castings....        | Law (271)  | 10,000-22,000                              | .....                                 | .....                      | .....                   |
| Magnesium Y        | .....                             | 0.21  | .....  | 1.58  | .....         | .....             | .....                      | General castings.....             | Law (271)  | 10,000-22,000                              | .....                                 | .....                      | .....                   |
| Magnesium Z        | .....                             | 3.2   | 12-18  | ..... | .....         | 3.15 Sn, 0.72 Pb. | .....                      | General castings.....             | B.S.       | 31,000-47,000                              | .....                                 | .....                      | .....                   |
| Aluminum A         | .....                             | 2.3   | .....  | 0.1   | .....         | 1.4 Fe            | .....                      | Sheet.....                        | B.S.       | 50,000                                     | .....                                 | .....                      | .....                   |
| Sheet B            | .....                             | 2.4   | .....  | 1.2   | .....         | 1.3 Fe            | .....                      | Sheet.....                        | B.S.       | 46,000                                     | .....                                 | .....                      | .....                   |
| Sheet C            | .....                             | 3.7   | .....  | 0.2   | .....         | 1.3 Fe            | .....                      | Sheet.....                        | B.S.       | 40,000                                     | .....                                 | .....                      | .....                   |
| Sheet D            | .....                             | 3.7   | .....  | 0.2   | .....         | 1.3 Fe            | .....                      | Sheet.....                        | B.S.       | 66,000                                     | .....                                 | .....                      | .....                   |
| Cast.              | .....                             | 0.4   | 0.4    | ..... | .....         | 0.7 Fe            | 2.84                       | Cast.....                         | B.S.       | 70,000                                     | .....                                 | .....                      | .....                   |
| Magnalium          | 93.4                              | 2.5   | 0.5    | 1.3   | .....         | .....             | 2.75                       | Castings.....                     | B.S.       | 26,000                                     | .....                                 | .....                      | .....                   |
| Aluminum           | .....                             | 3-4   | .....  | ..... | .....         | 1.5               | .....                      | .....                             | B.S.       | 26,000                                     | .....                                 | .....                      | .....                   |
| Electrometall      | .....                             | ..... | .....  | ..... | .....         | .....             | 2.8-3.57                   | .....                             | Krause (4) | 41,000                                     | .....                                 | .....                      | .....                   |
| Welding            | Contains Ni, Cu, Zn or Sn, Fe, Mg | ..... | .....  | ..... | .....         | .....             | .....                      | .....                             | Krause (4) | .....                                      | .....                                 | .....                      | .....                   |
| Bearing metal      | 95.5                              | 3     | .....  | ..... | .....         | 1 Sn, 0.5 Sb      | 2.75-3.1                   | .....                             | Krause (4) | 20,000-28,000                              | .....                                 | .....                      | .....                   |
| Bearing metal      | 92.2                              | 7.5   | .....  | ..... | .....         | 0.25 Sn           | .....                      | .....                             | Krause (4) | .....                                      | .....                                 | .....                      | .....                   |
| Bearing metal      | 97                                | 8     | .....  | ..... | .....         | 5 Sn              | .....                      | .....                             | Krause (4) | .....                                      | .....                                 | .....                      | .....                   |
| Bearing metal      | 94-98                             | 1.5-4 | .....  | ..... | 0.25-1.25     | .....             | .....                      | For rolling and forging....       | Krause (4) | 78,000                                     | .....                                 | .....                      | .....                   |
| Thermostat         | .....                             | ..... | .....  | ..... | 0.25-1.25 Ag. | .....             | .....                      | Substitute for silver.....        | Krause (4) | -40,000                                    | .....                                 | .....                      | .....                   |
| Aluminum-aluminum. | .....                             | ..... | .....  | ..... | 33 Ag.        | .....             | .....                      | .....                             | .....      | .....                                      | .....                                 | .....                      | .....                   |
| Aluminum-aluminum. | .....                             | ..... | .....  | ..... | .....         | .....             | 2.9                        | .....                             | .....      | 25,000                                     | .....                                 | .....                      | .....                   |
| Aluminum-aluminum. | .....                             | ..... | .....  | ..... | .....         | .....             | .....                      | .....                             | .....      | 34,000                                     | .....                                 | .....                      | .....                   |

Rolling.

o—Cast. r

A

TABLE XXII—LIST OF PATENTS COVERING LIGHT ALUMINIUM ALLOYS

| U. S.     | Date | U. S.     | Date | U. S.   | Date | German  | Date |
|-----------|------|-----------|------|---------|------|---------|------|
| 44,086    | 1864 | 1,104,369 | 1914 | 699,216 | 1902 | 144,777 |      |
| 632,743   | 1899 | 1,121,269 | .... | 662,952 | 1900 | 113,935 | 1899 |
| 652,833   | 1900 | 1,117,308 | .... | 639,600 | 1899 | 119,643 | .... |
| 867,194   | 1907 | 1,121,268 | .... | 646,432 | 1900 | 225,334 | .... |
| 451,406   | 1891 | 1,121,267 | .... | 662,951 | .... | 204,543 | 1907 |
| 684,207   | 1901 | 1,080,135 | 1913 | 639,084 | 1899 | 244,554 | .... |
| 1,212,374 | 1917 | 1,076,137 | .... | 611,016 | 1896 | 112,546 | 1899 |
| 1,227,174 | .... | 1,072,017 | .... | 580,711 | 1897 | 170,085 | 1903 |
| 1,224,362 | .... | 1,080,158 | .... | 501,553 | 1893 | 218,970 | .... |
| 1,175,655 | 1916 | 995,113   | 1911 | 480,445 | 1892 | 230,095 | 1909 |
| 1,146,185 | 1915 | 886,597   | 1908 | 451,405 | 1891 | 231,060 | 1909 |
| 1,130,785 | .... | 856,362   | 1907 | 443,431 | 1891 | 137,003 | 1911 |
| 1,092,500 | 1914 | 759,617   | 1904 | 373,231 | 1887 | 134,582 | .... |
| 1,095,653 | .... | 721,814   | 1903 | 320,149 | 1879 | 268,515 | .... |
| 1,099,561 | .... | 743,566   | 1903 | 30,301  | 1862 | 203,557 | 1906 |
| 1,102,618 | .... | 697,544   | 1902 | ....    | .... | 257,868 | 1911 |

ing somewhat more copper than No. 12 is manufactured by the Aluminum Castings Co. for service at elevated temperatures, for pistons etc. Much information covering both topics mentioned above is to be found in recent confidential military reports.

The alloys of magnesium and aluminium have attained some recognition as suitable for large optical mirrors. Mach and Schumann (290) have studied the adaptability of these alloys for this purpose and find that the alloy containing the compound  $Mg_3Al$ , is the best of the series. It is hard, and when polished has a reflecting power equal to or better than a silvered glass mirror. Special precautions must be taken to prevent the formation of blowholes; this is done by melting under a flux of salts, preventing the absorption of gas.

#### XI. CORROSION, DISINTEGRATION AND DETERIORATION OF ALUMINIUM AND ITS ALLOYS

The subject of the deterioration of aluminium and its alloys in service has naturally been of the greatest interest to the metallurgist and engineer alike; unfortunately it must be admitted that insufficient investigation has been made of the various rather obscure phases of it that some of the observed phenomena may be regarded as in any sense solved.

It may be preferable to distinguish four types of deterioration of aluminium alloys.

**Corrosion.** The corrosion, uniform or local, of the metal and its alloys is discussed above insofar as it has been investigated. An adequate direct comparison of the corrodibility of the various commercial casting alloys has never been made, although such information would be quite valuable, particularly to airplane designers and naval architects.

The following table gives an approximate comparison of the behavior of different alloys in sea water:

|                                                    | Loss of Weight in Sea Water<br>Lb. per Sq. Ft. per Month |
|----------------------------------------------------|----------------------------------------------------------|
| Rollad aluminium-copper alloys: 0 to 8 per cent Cu | 0.008 - 0.003                                            |
| Chilled cast aluminium-copper-manganese alloys: .. | 0.0004                                                   |
| Sand cast aluminium-zinc alloys: ..                | 0.001 - 0.002                                            |
| Duralumin sheets: ..                               | 0.0009 - 0.002                                           |
| Muntz metal: ..                                    | 0.0023                                                   |
| Naval brass: ..                                    | 0.0012                                                   |
| Mild steel: ..                                     | 0.0022                                                   |

When it is considered that the loss of volume of the light alloys per unit loss of weight is about 2.8 times that of brass or steel it is realized that particularly the copper and the zinc alloys cannot be used in sea water without some protective coating. The corrosion of alloys is in many cases not such a serious matter as they may be effectively protected from corrosion in most cases by a varnish or paint.

**Cracking.** Many cases of mysterious cracking of aluminium alloy castings, particularly of the zinc-

aluminium type, are undoubtedly due to shrinkage cracks originating during the solidification of the casting. It is well known that all aluminium alloys are fragile at temperatures just below the melting point or range; cracking due to faulty moulding or hard ramming is generally visible in the finished castings, but invisible and interior cracks are often formed which open up subsequently when stress is applied. The remedy for such defects lies of course only in better foundry and casting designing practice and in the use of alloys of least fragility at these temperatures. It is the consensus of opinion of foundrymen that zinc-aluminium alloys are inferior to aluminium-copper alloys in this respect. The addition of copper to alloys containing zinc materially improves this condition.

**Disintegration.** The spontaneous disintegration of alloys of aluminium with high percentages (50 per cent and more) of iron, manganese, nickel has been noted by investigators (Hindricks). These alloys when cast are hard and brittle but upon standing actually fall to powder.

The same type of phenomenon is observed in the case of aluminium-zinc alloys containing 50 per cent zinc and more (Pack, 302, Williams, 295). Such alloys annealed after casting are sound and dense, but upon standing (under no stress) particularly when exposed to slightly higher temperatures and moist air, swell and warp; cracks appear in the castings.

The final explanation of these changes has not been given; in fact the data are still discordant. Rosenhain and Archbutt (see above) found no evidence whatever of deterioration within ten months in sand-cast aluminium-zinc alloys containing up to 75 per cent of zinc. The changes which occur are due probably either to some change in constitution progressing in the alloy, or to differences in the coefficients of thermal expansion of the different constituents of the alloy. These changes have also been somewhat vaguely ascribed to the presence of impurity in the alloy (see discussion on Rosenhain-Archbutt paper, 438).

**Corrosion and Stress.** Under this group are considered some very interesting cases of deterioration due to the combined effect of stress and corrosion.

The experiments of Heyn and Bauer (130) have been described above, in which it was found that cold-rolled or hard aluminium sheet is exfoliated and blistered badly during corrosion in certain solutions, whereas the same material, annealed, corrodes quite uniformly in the same solutions. The effects of initial stress on the electrolytic solution of the metal and of the relief of initial stress by corrosion combine to produce this unusual phenomenon.

Somewhat more recently investigation has disclosed the fact that the tensile properties of hard drawn bars of an aluminium-zinc-copper alloy are very unfavorably affected by simultaneous corrosion (Cohn, 476). His results, obtained on an alloy of the following composition:

|           | Per Cent |
|-----------|----------|
| Zinc      | 9.40     |
| Copper    | 0.32     |
| Magnesium | 0.39     |
| Aluminium | balance  |

in the form of extruded (?) bars are given in Table XXIII.

It is noted that in the hard or cold-worked condition the alloy gave a much less ductility and strength when



TABLE XXIII—EFFECT OF STRESS AND CORROSION ON TENSILE PROPERTIES OF ALUMINIUM ALLOYS  
(Cohn, 471,473)

| Alloy                                                           | Temperature of Tensile Test and Medium in Which Test Was Made, Deg. C. | Description of Test Condition                                                           | Tensile Test—                     |                              | Remarks                           |
|-----------------------------------------------------------------|------------------------------------------------------------------------|-----------------------------------------------------------------------------------------|-----------------------------------|------------------------------|-----------------------------------|
|                                                                 |                                                                        |                                                                                         | Tensile Strength, lb. per Sq. In. | Elongation in 2 in. Per Cent |                                   |
| Extruded (and drawn?), alloy 1 per cent Zn—9.40 Cu—0.32 Mg—0.39 | 0—ice water..                                                          | Tested as noted in (column 2)....                                                       | 45,300                            | 16 0                         | Some fine cracks.                 |
|                                                                 | 20—air.....                                                            | Tested as noted in (column 2)....                                                       | 45,900                            | 16 1                         | Many cracks.                      |
|                                                                 | 20—water.....                                                          | Held in water at 70 deg. for 1 hour in contact with iron, tested (column 2)....         | 45,000                            | 15 3                         | Specimen covered with cracks.     |
|                                                                 | 20—water.....                                                          | Held in water at 20 deg. for 2 hours in contact with iron before testing (column 2).... | 38,500                            | 5-6                          | (1) Specimen covered with cracks. |
|                                                                 | 70—water.....                                                          | Held in water at 70 deg. for 1 hour, tested (column 2)....                              | 33,000                            | 5-6                          | (1) Specimen covered with cracks. |
|                                                                 | 70—oil.....                                                            | Held in oil at 70 deg. for 1 hour, tested (column 2)....                                | 37,000                            | 4 2                          | Specimen covered with cracks.     |
| Above alloy annealed at 400 deg. C.                             | 0—ice water.....                                                       |                                                                                         | 44,000                            | 21.1                         |                                   |
|                                                                 | 20—air.....                                                            |                                                                                         | 42,600                            | 20.8                         |                                   |
|                                                                 | 70—water.....                                                          |                                                                                         | 35,800                            | 17 4                         |                                   |
| Duralumin heat-treated                                          | 0—ice water.....                                                       |                                                                                         | 64,400                            | 20 0                         |                                   |
|                                                                 | 20—air.....                                                            |                                                                                         | 62,400                            | 20 0                         |                                   |
|                                                                 | 70—water.....                                                          |                                                                                         | 60,900                            | 20 0                         |                                   |
| Duralumin heat-treated and cold worked                          | 0—ice water.....                                                       | Held in water for 3 hours, in contact with iron, tested (column 2)....                  | 75,300                            | 6 9                          |                                   |
|                                                                 | 20—air.....                                                            |                                                                                         | 76,000                            | 6 1                          |                                   |
|                                                                 | 20—water.....                                                          |                                                                                         | 75,100                            | 6 9                          |                                   |
|                                                                 | 70—water.....                                                          |                                                                                         | 72,800                            | 5 5                          |                                   |

(1) Broke outside of gage length.

tested in water than when in air. After annealing this effect was reduced. Duralumin showed practically no sensitivity to such treatment either as heat-treated or as heat-treated and cold worked.

These experiments were undertaken in order to explain the cracking which had been noticed of sections, rods and tubes of this commercially much used alloy when stored and under no stress. Similar experience has been recorded in the case of the breaking and em-

both steel and wood in construction in which both strength and lightness are a prime requisite.

XIII. HEAVY ALUMINIUM ALLOYS

The use of aluminium as an alloying element is perhaps as extensive in alloys containing an excess of other metals as in the light alloys.

Alloys of from 3 to 10 per cent of aluminium in copper are manufactured in both the cast and in the rolled

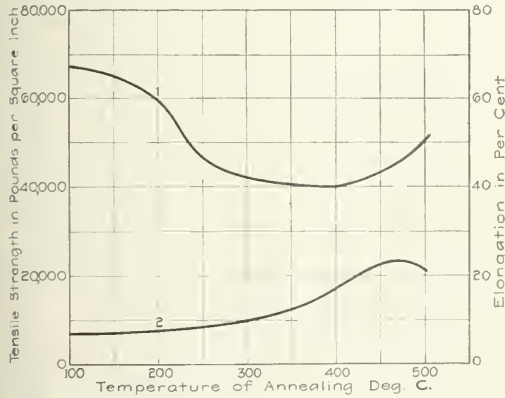


Fig. 26—Effect of Annealing Duralumin (Cohn, 471, 473). 1. Tensile Strength; 2. Elongation. Sample Annealed and Cooled in Air

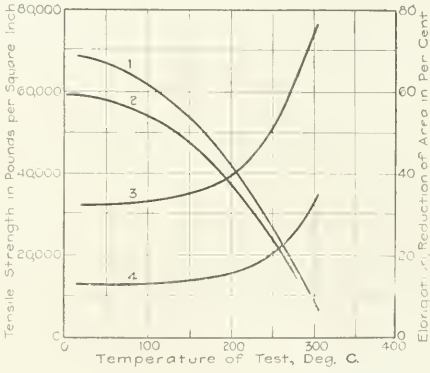


Fig. 27—Effect of Temperature on Physical Properties of Duralumin (Cohn, 471, 473). 1. Tensile Strength; 2. Yield Point; 3. Reduction of Area; 4. Elongation.

brittling of hard-drawn aluminium wire electric conductors.

XII. COMPARISON OF DENSITY AND MECHANICAL PROPERTIES OF ALUMINIUM ALLOYS WITH OTHER MATERIAL OF CONSTRUCTION

In Table XXIV are compared the tensile properties for several materials used for construction in relation to their densities. Steels have been chosen for comparison which have approximately the same ductility as the duralumin. Douglas fir has been included as representing the best wood available for aircraft wood construction. The values given bring out the fact that, weight for weight, duralumin and similar light alloys are as strong as the best steels and for the same strength give greater stiffness. There appears to be no doubt of the adequacy of such light alloys as substitutes for

or wrought form under the name of aluminium bronzes. The properties of these alloys are described by Corse and Comstock (478), Corse (482), Read (490), Carpenter and Edwards (380), and many others.

An aluminium bronze containing 10 per cent of aluminium will have the following tensile properties when cast to size (478):

Tensile strength, lb. per sq.in.....75,000  
Elongation in 2 in. per cent..... 24

A modification of this alloy containing 10 per cent of iron, 10 per cent of aluminium and treated with titanium will give the following tensile properties when cast to size:

Tensile strength, lb. per sq.in.....80,000  
Elongation in 2 in. per cent..... 30

Aluminium bronze for rolling containing usually

<sup>2</sup>Private communication from Mr. W. M. Corse.

TABLE XXIV—COMPARISON OF MECHANICAL PROPERTIES OF SOME MATERIALS OF CONSTRUCTION

| Material                                       | Tensile Test            |                                       |                                  |                             |                                |                              |                                |                                  |                                |              | Ratio of weight, diameter and transverse stiffness of a round bar of duralumin having same working load to that of a similar unit bar of material opposite |                 |
|------------------------------------------------|-------------------------|---------------------------------------|----------------------------------|-----------------------------|--------------------------------|------------------------------|--------------------------------|----------------------------------|--------------------------------|--------------|------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------|
|                                                | Density, gr. per cu.in. | Modulus of Elasticity, lb. per sq.in. | Tensile Strength, lb. per sq.in. | Yield Point, lb. per sq.in. | Elongation in 2 in., Per Cent. | Reduction of Area, Per Cent. | Working Stress, lb. per sq.in. | Ratio = Tensile Strength Density | Ratio = Working Stress Density | Ratio Weight | Ratio Diameter                                                                                                                                             | Ratio Stiffness |
| Heat-treated alloy steel.....                  | 7 80                    | 30x10 <sup>6</sup>                    | 115,000                          | 115,000                     | 14                             | 45                           | 55,000 (2)                     | 19,200                           | 7,100                          | 1 35         | 1 92                                                                                                                                                       | 4 45            |
| Rolled alloy steel sheet.....                  | 7 80                    | 30x10 <sup>6</sup>                    | 100,000                          | 75,000                      | 20                             | ..                           | 37,000 (2)                     | 12,800                           | 4,700                          | 0 89         | 1 57                                                                                                                                                       | 2 05            |
| Rolled carbon steel sheet.....                 | 7 80                    | 30x10 <sup>6</sup>                    | 75,000                           | 45,000                      | 25                             | ..                           | 23,000 (2)                     | 9,600                            | 2,900                          | 0 55         | 1 24                                                                                                                                                       | 0 78            |
| Rolled and heat-treated duralumin.....         | 2 85                    | 10x10 <sup>6</sup>                    | 60,000                           | 30,000                      | 15                             | ..                           | 15,000 (2)                     | 21,000                           | 5,300                          | 1 00         | 1 00                                                                                                                                                       | 1 00            |
| Rolled zinc-aluminum-copper alloy (1) (a)..... | 3 29                    | 9x10 <sup>6</sup> (?)                 | 71,000                           | 61,000                      | 21                             | 38                           | 30,000 (2)                     | 21,500                           | 9,100                          | 1 71         | 1 41                                                                                                                                                       | 1 33            |
| (b).....                                       | 3 29                    | 9x10 <sup>6</sup> (?)                 | 52,400                           | 36,000                      | 18                             | ..                           | 18,000                         | 15,900                           | 5,400                          | 1 02         | 1 10                                                                                                                                                       | 0 48            |
| Douglas fir (4).....                           | 0 47                    | 1 64 x 10 <sup>6</sup>                | 6,100 (3)                        | 4,400                       | ..                             | ..                           | 1,200 (3)                      | 13,000                           | 2,500                          | 0 47         | 0 89                                                                                                                                                       | 21 10           |

(1) Containing 25 per cent Zn, 3 per cent Cu, (a) in form of 4-in. hot-rolled bar (Rosenhain-Archbutt) ———, (b) as rolled 0.156 in. diameter sheet, annealed.

(2) Using working stress of  $\frac{\text{yield stress}}{2}$ .

(3) Adopted by American Railway Engineering Association.

(4) These values are determined in the transversal bending test.

about 7.5 per cent of aluminium. This alloy when rolled will give the following approximate values of the tensile properties:

Tensile strength, lb. per sq.in. .... 80,000-90,000  
Yield point, lb. per sq.in. .... 15,000-20,000  
Elongation in 2 in., per cent. .... 20-30

Aluminium is extensively used as a deoxidizer in both iron, steel and non-ferrous metals, and also in the manufacture of steel to produce blowhole-free ingots of steel. Brinell (479) finds that this effect of aluminium preventing blowhole formation in acid-steel ingots is about 13 times as great as that of silicon and about 90 times as great as that of manganese. He gives the formula

$$D = Mn + 5.2 Si + 90 Al.$$

If  $D = 2$ , blow-hole-free acid steel ingots are produced 24 by 24 cm. when poured into an almost cold iron mold, 5 cm. thick.

#### XIV. SPECIFICATIONS FOR ALUMINIUM AND ITS LIGHT ALLOYS

There are given below references to published specifications for commercial aluminium and its light alloys.

##### A. Aluminium.

(a) Ingot aluminium, U. S. Navy Department, No. 47A1a, 1915. International Aircraft Standards Board, No. 2N1, 1917.

(b) Aluminium sheet, International Aircraft Standards Board, No. 3N12, 1917.

(c) Aluminium bars, International Aircraft Standards Board, No. 3N23, 1918.

(d) Aluminium tubes, International Aircraft Standards Board, No. 3N20, 1917.

##### B. Aluminium alloys.

(e) No. 12 casting alloy, Society of Automotive Engineers, No. 30, 1912. International Aircraft Standards Board, No. 3N11, 1917.

(f) No. 31 casting alloy, Society of Automotive Engineers, No. 31, 1912.

(g) Casting alloy, U. S. Navy Department, No. 49A1, 1915.

(h) Duralumin sheet, International Aircraft Standards Board, No. 3N16, 1917.

(i) Duralumin bars, International Aircraft Standards Board, No. 3N18, 1918.

(j) Duralumin tubes, International Aircraft Standards Board, No. 3N17, 1918.

### Thick Deposit of Electrolytic Nickel

Among the interesting exhibits at the recent Chemical Exposition was one which should have been marked with the "bull's eye" to indicate that it represented manufacture since the war. This comprised a number of shapes of pure electrolytic nickel which had been deposited on molds to a thickness of as much as one-eighth inch. Heretofore electroplaters had considered it impossible to make satisfactory nickel plate thicker than 0.001 to 0.002 of an inch in thickness because heavier plates were brittle and porous and tended to scale from the metal on which they were deposited. According to the new process represented in the exhibit, and which is the invention of Mr. C. P. Madsen, a dense deposit can be made practically as thick as desired. The process is an excellent example of the art of galvanoplasty, or the production of articles by electrodeposition on molds, which has been used rather extensively in Europe for manufacture of copper articles such as tubing. It has not found extensive commercial development in this country.

The nickel deposited by the Madsen process is homogeneous and malleable, showing a surface free from pits or roughness. In its physical properties it is comparable to rolled nickel, having a tensile strength of 62,000 pounds per square inch with an elongation of 20 per cent. It is impervious even at a pressure of 850 pounds per square inch when the wall of the vessel is but 20/100 of an inch thick. The nickel can be deposited in forms which are now spun or drawn, but more particularly in intricate forms which it is not possible to make by any other known means. Its cost is low because forms can be deposited direct from an impure anode or even from salts in solution. The cost for articles that can be spun is less than by the spinning process on account of the high cost of preparing sheets for the latter method. Since the Madsen nickel has a purity of 99.8 per cent it possesses valuable properties for chemical purposes. On account of the military value of the process it is impossible to give many details but it is the desire of the Government that some publicity should be given to the matter in order that those who might make use of it will know of its existence. Correspondence can be directed to Dr. F. G. Cottrell of the Bureau of Mines, Washington, D. C., and Mr. C. P. Madsen, 44 Walnut St., Newark, N. J.

## Personal

MR. A. W. AMBROSE, acting chief petroleum technologist of the U. S. Bureau of Mines, is spending a few weeks in California on investigations in connection with the work of the Bureau. MR. C. H. BEAL, petroleum technologist of the Bureau, is taking Mr. Ambrose's place during his absence from Washington.

MR. HARRY L. BARNITZ, formerly sales agent for the International Oxygen Company, has severed his connection with that firm and is engaged in consulting engineering in matters relating to oxygen and hydrogen.

MR. A. E. DRUCKER is now connected with the firm of Howard Morinni & Co., Inc., at 111 Broadway, New York City, as manager of their chemical and metallurgical departments.

MR. FRANK P. FAHY, consulting magnetic engineer, Hudson Terminal Building, New York City, has been awarded the John Scott Legacy medal and premium for the development of the Fahy permeameter, by the City of Philadelphia, which acted upon the recommendation of the Franklin Institute.

MR. CLAUDE FERGUSON has resigned as superintendent for the Copper Queen Gold Mining Co., at Stoddard, Arizona, to accept a similar position with the Consolidated Arizona Smelting Co., in charge of the operation of the De Soto and Swastika mines.

PROF. V. H. GOTTSCHALK, formerly professor of chemistry at the Missouri School of Mines and Metallurgy, has been appointed director of pure research for the American Cotton Oil Co. and subsidiaries. His headquarters are at Chicago.

MR. WILLIAM H. HAMPTON has been placed in charge of and development of miscellaneous gas defense apparatus under Major Waldemar Kops, Gas Defense Division, Chemical Warfare Service, U. S. A., Long Island City.

MR. W. W. JONES, formerly manager of the New York office of Frederick Stearns & Company, has accepted the appointment of manager of the essential oil and gum department of the National Aniline & Chemical Company, Inc., 21 Burling Slip, New York.

MR. R. V. MILLS, petroleum technologist of the U. S. Bureau of Mines, with headquarters in San Francisco, is at present in West Virginia where he will be engaged in Bureau work for several months.

MR. C. C. O'LOUGHLIN, formerly with Braum-Knecht-Heimann of San Francisco, has joined the sales force of the Hoskins Mfg. Company of Detroit.

DR. E. C. SHOREY has resigned from the Division of Chemical Investigation in the Bureau of Soils, U. S. Department of Agriculture, to accept a position at the Marcus Hook, Pa., plant of the National Aniline and Chemical Co.

MR. H. E. SHRIVER, has accepted a position as chemical engineer with the Air Nitrates Corporation at their electrochemical plant at Muscle Shoals, Ala., in a supervisory position in Unit 5. He was formerly assistant chemist, South Carolina Experiment Station, Clemson College, S. C.

MR. PAYNE G. WEST has been appointed assistant manager of field sales for the Lakewood Engineering Company of Cleveland. He was formerly associated with the T. L. Smith Co., Milwaukee, as sales manager.

MR. O. L. THOMAS is now at the U. S. Government powder plant at Jacksonville, Tenn., as chief supervisor of caustic soda manufacture and soda ash recovery, having been transferred from the Experimental Station of E. I. duPont de Nemours & Co., Wilmington, Del.

## Book Reviews

**CRUDE RUBBER AND COMPOUNDING INGREDIENTS.** A text book of Rubber Manufacture. By Henry C. Pearson, Editor of the *India Rubber World*. Third Edition, 1918. New York: The India Rubber Publishing Co. Price \$10.00.

A practical book of information on rubber manufacture written by a practical man for the benefit of men actively engaged in the production of rubber goods. It can hardly be classed as a scientific work, nor is it aimed at the rubber chemist though he may get many valuable ideas from it. The book is well written and is readily understandable by any one with ordinary intelligence. It includes many old and time-tried ideas, some of which have been found unworkable, but on the whole it teems with suggestions for the man who faces the every-day problems of rubber production and research.

The following is a brief review of its contents:

CHAPTER I. Deals with the nature of rubber, botany of the various rubber vines and trees, and gives the origin of many commercial varieties. Both the wild and plantation rubbers are briefly covered. The writer emphasizes a fact often lost sight of which is the most characteristic if not the most important property of rubber, i.e., "it can be repeatedly stretched to many times its length, returning each time to about its first dimensions." He still holds to the old fashioned idea that rubber is composed of an adhesive principle which is readily soluble and a nervy insoluble substance which gives rubber its elasticity. Most modern rubber chemists believe that rubber exists in different degrees of polymerization and that there is no such thing as a soluble and an insoluble portion. It is to be regretted that no analytical data are given for the different rubbers.

CHAPTER II. Contains a rather good description, botanically and chemically, of some little known rubbers and pseudo gums; particularly interesting to one working with adhesive problems.

CHAPTER III. Deals with methods of coagulation. A brief review of the steps in coagulation and many different processes which have been advanced at one time or another.

CHAPTER IV. Vulcanizing processes, ingredients, and the optimum cure. The author does not restrict himself to sulphur and sulphur chloride, but gives a number of processes which were advanced at the time the rubber industry was trying to get around Goodyear's patents. One or two purely trade preparations are given without mention of their composition, maker, or any information which would allow one to duplicate or even obtain them. The work of Eaton and Grantham on the optimum cure is briefly reviewed.

CHAPTER V. A review of the literature on organic and inorganic accelerators from the standpoint of the practical rubber man. The author states that mineral accelerators undergo no chemical change during vulcanization, which is incorrect. Nothing is given on the preparation nor chemical structure of the various organic accelerators.

CHAPTER VI. An excellent review of various inorganic fillers. Would have been more valuable to the chemist if a little more analytical data had been given. In the opening paragraph the author is not sufficiently definite as to the purpose of compounding which is not adulteration of the rubber but is practised chiefly to bring out certain desirable properties such as strength, elasticity, toughness, etc., which render the product superior to anything found in nature. Both gas-black and zinc oxide which are the most important and valuable fillers known today are placed among the pigments.

CHAPTER VII. A review of practically all the rubber substitutes which have been advanced within recent years. Many are absolutely worthless and unworkable, but the chapter will prove of value to the investigator who seeks ideas.



CHAPT. VIII. A very good review of hard rubber and gutta percha substitutes, including cellulose products. A collection of useful information.

CHAPT. IX. Deals with resins, balsams, etc., many of which have been used at one time or another in rubber compounding.

CHAPT. X. An excellent survey of the pigments used in coloring rubber. More analytical data would have been desirable.

CHAPT. XI. Acids, alkalis, and their derivatives used in rubber manufacture. Information for the rubber man who has had no training in chemistry.

CHAPT. XII. Vegetable and other oils at one time used with rubber. Many of those given are now obsolete.

CHAPT. XIII. A review of rubber and resin solvents. Several trade preparations are given space without mention of their composition, etc.

CHAPT. XIV. A survey of miscellaneous processes used in factory practice, many of which are not to be found elsewhere.

CHAPT. XV. Synthetic rubber. A review of Luff's paper in the *Journal* of the Society of Chemical Industry. It is not sufficiently definite and is handled without structural formulae. It is intended for the non-technical man.

CHAPT. XVI. A review of Ostromislensky's work on vulcanization; rather a complete abstract.

CHAPT. XVII. The general business of reclaiming is briefly described and a number of individual processes are mentioned. It is to be regretted that patents and other references are not given.

CHAPT. XVIII. Deals with the testing and analysis of crude and vulcanized rubber. A number of specifications, various standard methods of testing, and analysis are given in detail.

CHAPT. XIX. A brief survey of the methods of preparation of rubber for use. A number of typical compounds are given. These have no practical value and many of the rubbers called for are no longer obtainable. They do not represent modern compounding practice.

CHAPT. XX. Treats of Gutta-Percha and Balata, and is very well done. The information given is of considerable value.

The volume is what the author intends—a practical book on rubber for the practical man.

\* \* \*

THE FERTILIZER HAND BOOK. 456 pages. Price \$1.50. Philadelphia: Ware Bros. Company.

The eleventh edition of this handbook is now ready. The trade statistics include everything on fertilizer given out by the Government. The list of fertilizer manufacturers includes over a thousand firms. The directories of the cottonseed oil mills and the packing and rendering establishments are brought up to date. The segregated sections are: A, fertilizer manufactures; B, allied directory—companies having products used in fertilizer, such as ammonia; C, phosphate rock; D, fertilizer machinery; E, raw materials, such as potash; F, fertilizer merchants; G, chemist and engineers; H, cottonseed oil mill equipment; and I, packers' and renders' machinery. Special articles written by specialists give interesting treatment on some major subjects, such as: "The Composition of Cottonseed" by Thos. C. Law; "The Use of Lime in Agriculture" by John H. Voorhees; "Potash in 1916-1917" by Hoyt S. Gale; "Sulphur and Pyrite in 1916" by Philip S. Smith; "Maintaining Fertility on Fertilizers Alone" by E. G. McCloskey; and "The Production of Phosphate Rock in 1916" by R. W. Stone.

\* \* \*

A DIRECTORY OF ENGINEERS. Published by the American Association of Engineers, Chicago, Ill. Cloth 6 x 9 in. Pages 192. Price \$2.00.

This directory gives a brief synopsis of each member's experience and training, which will be of definite usefulness to the employer of engineers, who will be able to tell whether an applicant fills his needs without the loss of time from unnecessary interviews.

The 2204 members registered in the Directory are divided according to experience, as follows:

|                                                       | Per Cent |
|-------------------------------------------------------|----------|
| Members having Civil Engineering experience.....      | 91.9     |
| Members having Mechanical Engineering experience..... | 24.8     |
| Members having Electrical Engineering experience..... | 12.8     |
| Members having Mining Engineering experience.....     | 5.7      |
| Members having Chemical Engineering experience.....   | 2.9      |

## Current Market Reports

### The Non-Ferrous Metal Market

**Monday, Oct. 7.**—The Government control over the metal markets is becoming more systematic. Elsewhere in this number the rules and regulations on platinum are printed, which give complete data for meeting any munition requirements that may arise during the present situation.

**Aluminum.**—The Government prices on ingots 98 to 99 per cent Al are \$660 a ton f.o.b. plant in 50-ton lots; \$662 down to 15-ton lots; and \$666 down to 1-ton lots, which prices will continue the remainder of the year. Prices per pound for small lots vary from 40 to 45c; sheet aluminium, 18ga. and heavier, 42c; powdered aluminium, 100 mesh, 70c.

**Antimony.**—The demand is quiet and prices have been on a slight decline at 13½c to 14c.

**Copper.**—The price of \$520 per ton for car load lots and 27.3c. per pound for small lots is expected to be continued at the conference to be held the latter part of this month.

|                                 |     |        |          |
|---------------------------------|-----|--------|----------|
| Copper sheets, hot rolled.....  | lb. | \$0.36 | —\$0.37½ |
| Copper sheets, cold rolled..... | lb. | .37    | — .38½   |
| Copper bottoms.....             | lb. | .44    | — .45½   |
| Copper rods.....                | lb. | .36    | — .37    |
| Copper wire.....                | lb. | .29½   | — .30    |
| High brass wire.....            | lb. | .28½   | — .29    |
| High brass sheets.....          | lb. | .28    | — .29½   |
| High brass rods.....            | lb. | .26½   | — .28    |
| Low brass wire.....             | lb. | .32    | — .34½   |
| Low brass sheets.....           | lb. | .32    | — .34    |
| Low brass rods.....             | lb. | .33½   | — .35    |
| Brazed brass tubing.....        | lb. | .37    | — .39    |
| Brazed bronze tubing.....       | lb. | .42½   | — .44½   |
| Seamless copper tubing.....     | lb. | .43    | — .45    |
| Seamless bronze tubing.....     | lb. | .45    | — .46    |
| Seamless brass tubing.....      | lb. | .37½   | — .39½   |
| Bronze (gold) powder.....       | lb. | 1.00   | — 1.75   |

**Lead.**—The lead market is limited by selling restrictions. Producers must sell at a uniform and pre-arranged price. In car load lots at East St. Louis, the price is \$155 per ton. In New York, all speculative and traders' lead has disappeared. The Lead Committee apportions lead at 8.05c. to legitimate consumers.

**Manganese.**—The scale prices on page 629 of *CHEMICAL & METALLURGICAL ENGINEERING*, June 15, prevail; the highest price per unit being \$1.35.

**Zinc.**—Spelter is declining slightly; New York delivery being quoted at 9.2 to 9.25c. for spot and October. East St. Louis quotations are \$174 to \$178, per ton in car load lots. Sheet zinc 15c. and zinc dust 300 mesh) 16c. per pound in 1600-lb. casts.

**Silver.**—The Government price of \$1.01½ is hoped to promote production. Exports to the orient and our film industry have created a growing demand.

**Tin.**—The market is awaiting further development on the inter-Allied conference on tin. The War Industries Board will soon announce regulation prices and control the distribution of our 80,000-ton allocation. Tin is priced at 80c. per pound nominally.

**Tungsten.**—The western producers of scheelite are reluctant in offering at \$25.50 per unit. High grade wolframite is bringing \$25. Off-grade ores vary from \$20 to \$24.

### OTHER METALS

|                |        |        |         |
|----------------|--------|--------|---------|
| Bismuth.....   | lb.    | \$3.50 | —\$3.65 |
| Cadmium.....   | lb.    | 1.50   | —       |
| Cobalt.....    | lb.    | 2.50   | — 3.50  |
| Magnesium..... | lb.    | 1.75   | — 2.00  |
| Mercury.....   | 75 lb. | 125.00 | —       |
| Nickel.....    | lb.    | 1.95   | —       |
| .....          | lb.    | .40    | — .43   |
| Iridium.....   | oz.    | 175.00 | —       |
| Palladium..... | oz.    | 135.00 | —       |
| Platinum.....  | oz.    | 105.00 | —       |

## The Iron and Steel Market

No decrease whatever in the War Industries Board's estimate of the steel requirements for the current half-year is in prospect as a result of the exhaustive study the Board has been making in the past few weeks of the steel supply in proportion to requirements in each of the important war activities. At no time has the Board made public the precise tonnage required by any activity, its statements always dealing with the total only, and it is quite possible that the amount of steel expected to be needed by some departments through the remainder of this year may have been reduced, but if so such reductions have evidently been balanced by increases in the requirements in other quarters.

A long list has been given out showing curtailments in commercial consumption of steel arranged with manufacturers of various wares, from clothes wringers to baby buggies and talking machines, but the tonnage involved in any item is not large, and the benefit to the prosecution of the war may be as great from the labor that will be saved from working up the material as from the saving of material itself. There are two exceptions to this general statement, referring to the tin-plate and agricultural implement industries. Early in September there was a ruling that the tin-plate industry should limit its production in the fourth quarter of the year to 70 per cent of its production in the fourth quarter of 1917, which it was estimated would save about 150,000 tons of steel, and negotiations have since been in progress between the Food Administration and the packers of various non-perishable food products looking to drastic curtailment in their consumption of tin-plate. As the manufacture of tin-plate is prohibited except on Government orders and for packers of food products, the prospect is that the output will actually prove to be much below the 70 per cent originally prescribed. The other tonnage exception to the conservation program, the agricultural implement industry, is estimated to consume 2,000,000 tons of pig iron and steel a year, and the industry is to curtail its consumption by 25 per cent for the twelve-month beginning October 1, as compared with the preceding twelve-month. Its operations for any particular portion of the twelve-month are not limited, except as material may not be received with the degree of priority accorded. Of the 500,000-ton saving expected, more than half is in pig iron, but this is practically equivalent to a corresponding saving in steel since for a long time past the production of steel has been limited by the supply of pig iron.

As to the quantity of finished rolled steel required by the entire war program, including essential commercial consumption represented in the preference list, during the current half year, the War Industries Board's original estimate, made early in July, was 20,000,000 net tons. By successive stages this was increased to 23,000,000 tons and afterward it was stated that the total might be closer to 25,000,000 tons. The Board first estimated the prospective supply at 16,500,000 net tons and then increased its estimate to 17,000,000 tons. Production during July, August and September was probably fully 9,000,000 tons, and for the fourth quarter an estimate of 10,000,000 tons seems conservative, barring accidents such as a breakdown in transportation. As the gap is hardly likely to be bridged by an unexpectedly large production or by a decrease in the estimated requirements, the determination as to what lines of consumption will receive steel and what lines will not appears to be left to the priority and preference system. As this would cut steel off entirely from some important lines of consumption it is possible that there will be more granting of individual priorities for specific lots of material in special cases.

It is known that there have been large increases in certain war steel requirements since the War Industries Board estimated the half-year's requirements at 23,000,000 net tons. General Pershing's requirements have been increasing almost constantly, particularly as to shells and rails. The Railroad Administration desires a larger tonnage of rails to the end of the year than was originally contemplated, and it desires the completion of the 100,000 freight cars ordered a few months ago to be expedited in

order to clear the way for additional orders. Incidentally, it contemplates a very heavy locomotive building program for 1919.

### PIG-IRON PRODUCTION

Pig iron production, in gross tons, in the first half of 1918 is officially reported as follows, production in 1917 being given for comparison:

|                             | 1st half<br>1917 | 2nd half<br>1917 | 1st half<br>1918 |
|-----------------------------|------------------|------------------|------------------|
| Basic .....                 | 8,620,604        | 9,051,058        | 8,617,692        |
| Bessemer and low phosphorus | 7,041,426        | 6,673,306        | 6,006,607        |
| Foundry and ferrosilicon    | 2,602,448        | 2,725,810        | 2,518,721        |
| Malleable .....             | 509,982          | 505,597          | 607,318          |
| Forge .....                 | 198,914          | 146,793          | 197,636          |
| Spiegel and ferro-manganese | 210,432          | 242,678          | 237,228          |
| All other .....             | 74,429           | 17,739           | 42,528           |
| Total                       | 19,258,235       | 19,362,981       | 18,227,730       |

The smallness of the production in the first half of this year furnishes no surprise, as the approximate total has been known for three months. The information furnished as to segregation by grades is altogether new, and has an important bearing upon the matter of steel supply. It is well recognized that production of steel hinges upon pig-iron supply, as many steel departments could make more steel if they had more pig iron, and it is pertinent to inquire why so large a tonnage of foundry and malleable iron has been made. The large production in the second half of 1917 may be passed over, with the observation that it might have furnished a reserve stock at the end of the year, and the production in the first half of this year is to be compared with the output in the first half of 1917, there being no decrease, when the output of basic iron was stationary and Bessemer decreased a million tons. There is good ground for holding that in the interest of the war program the consumption of pig iron by iron foundries could have been reduced in the interest of providing more pig iron for steel making, and it is to be hoped that if the matter has not been fully adjusted by this time it will now be taken firmly in hand.

Pig-iron production has been increasing, as the progress of the season brings lower humidity, and there are reports of better quality coke being received by furnaces. The Fuel Administration continues its strenuous efforts, begun early in September, to cause better coke to be made. Steel production is likewise increasing and the current month is expected to make a new record.

There is no steel market, as the steel mills are unable to take full care of priority orders, with an occasional stray shipment of preference steel, the latter in almost every instance being against very old orders. Class D steel is being booked to an extent by some mills, with the distinct understanding that there is no visible prospect of the order being filled during the war.

## The Chemical Market

**COAL TAR PRODUCTS:**—In the coal tar products, the situation underwent little change during the interval. Of the important crudes, phenol has been in better demand with prices having an upward tendency. Benzol however, has been one of the lagging items and its position has developed rather weak. Prices for most of the intermediates are firm except in a few instances where prices have advanced. Paratraniline is still urgently demanded, as is paraamidophenol, both the base and hydrochloride. The demand for dimethylaniline has not eased up in interest though stocks are seemingly becoming more scant which it can be stated applies to situation of the intermediates in general.

**Phenol:**—Stocks are apparently becoming depleted owing to the pressure of demand that has been in evidence during the past week. Interest is still persistent for export purposes and the local demand has increased to a very noticeable extent. Owing to the condition of their stocks some large manufacturers are unable to offer quotations and where offerings are made prices have been advanced 2c. to 3c.

**Benzol:**—Buying interest has been lacking for this item to a considerable extent and its position in the market is rather



weak for the past week. Stocks are reported to have accumulated in large quantities and prices for the material in tank cars have declined 1c. while the drum material remains at about the same level.

**Aniline Oil:**—A firming up situation has developed in this market and cheap stocks which were offered early in the week are seemingly no longer available and prices on the whole have advanced from 1c. to 2c. relative to seller.

**Aniline Salts:**—The undertone is firm and trading is reasonably active, with stocks in accordance with the consuming demand. Prices are quotably unchanged and remain at firm levels.

**Paranitraniline:**—The item continues to be the feature of the intermediates and no immediate encouragement is offered by manufacturers who apparently have more or less difficulty in fulfilling their contracts, and holders of spot material are exacting all sorts of prices.

**Benzidine:**—The volume of business passing is apparently having no effect on the available stocks, which are reported to be in good supply. The activity of the base material is more noticeable for export purposes while domestic consumption is fair and steady. Prices continue at the same firm levels.

**H. Acid:**—Producers are all sold up and very little supplies are available in the resale market. The situation on the whole is virtually nominal.

**Paranitrotoluid:**—Factors in this line continue to state they are all sold up, however frequent lots appears in the resale market and are held for rather high prices.

**Paratoluidine:**—The same position applies to this item, manufacturers are in no position to offer but are experiencing difficulty in fulfilling their contracts owing to the situation of crude material. Prices however remain firm at the former levels.

**Benzaldehyde:**—There is a strong demand for this item, but stocks of the various grades are only in small lots here and there. However for material that is offered there is a ready market but prices vary and the situation is in favor of the seller.

**Puro Amidophenol:**—The products of some new concerns have been offered for sale on the market, but the trade is awaiting the results of tests. However the more popular products which are mainly of a high grade are rather scarce and during the week were advanced in price.

**Phthalic Anhydride:**—Export interest is still very much in evidence and the product for local consumption is also in good demand. The situation of this market is very firm and prices remain at firm levels.

**Monochlorbenzol:**—The item is one of those which appears to be neglected and supplies are reported as plentiful. Quotations heard are subject to no change.

**HEAVY CHEMICALS:**—During the intervening period trading has been rather quiet and no very noticeable changes have set in, although it may be stated that the market on the whole is firm. Caustic soda and soda ash still maintain their prominence and the volume of business passing for these commodities is the feature of the market. The stocks of bleaching powder are no easier and there seems to be no limit in sight relatives to price and no encouragement is offered pertaining to a more liberal supply. Price changes for the week are not numerous; however where made tended toward upward levels. Stocks of the alums are more noticeably scarce, particularly the ammonia, and some sellers are holding at higher prices.

**Soda Ash:**—Unusual quantities of the material have been changing hands during the past two weeks and the position of the product in the market is very firm. Sales during the period included single bags at \$2.65 to \$2.70 in warehouse and double bags at western shipping point were sold for \$3.40 with sales of barrel material having been consummated at \$3.25. Single bags in New York were quoted at the close at \$2.65 to \$2.70 and in Troy single bags were held at \$2.70 with \$2.70 quoted in Philadelphia. Double bags were quoted at \$3.40 middle west, while at Chicago the material was held at \$3.45 and \$3.20 Painesville. The position of barrel material appeared to have been somewhat easier during the latter part of the week and some sales were passing a trifle lower than the market, at that

time. The various quotations on barrel material were as follows: New York \$3.25 and 3c. works, Chicago \$3.15 and in St. Louis prices were firm at \$3.10. Dense ash in bags were held at \$3.90 to \$4.00 which was also about the market position of the dense in barrels.

**Caustic Soda:**—The situation is causing considerable comment, due to the fact that during the previous week, interest in the item was not particularly noticeable, but a firming up set in and at the close some lively trading was in evidence. Prices advanced for the solid material from \$4.30 to \$4.50 with sales having been closed at the latter price. Material rolling to New York during the last week is said to have been of sufficient quantity for the consuming demand. Buyers were seemingly aware of the prevailing conditions and were awaiting developments before attempting to enter the market. Offerings however in the market were in fair quantities at prices ranging from \$4.40 to \$4.50 ex warehouse and \$4.40 works. The ground material was generally quoted at from \$4.30 to \$4.50 ex warehouse.

**Sulphuric Acid:**—The notable feature of this item and of great moment to the trade was the recent announcement of the War Industries Board relative to the maximum prices effective from September 30 to December 30 as follows: 60 degrees Baume \$16 per ton of 2000 pounds, 66 degrees Baume \$25 per ton of 2000 pounds, 20 per cent Oloum, \$28 per ton of 2000 pounds; f.o.b. at manufacturers' works in sellers' tank cars. All strengths less than 92 per cent H<sub>2</sub>SO<sub>4</sub> shall be calculated from the price for 60 degrees Baume. All strengths above 92 per cent H<sub>2</sub>SO<sub>4</sub> shall be calculated from the price for 66 degrees Baume. In carboys in carload lots one-half cent per pound extra. In carboys, in less than carload lots, three-fourths cent per pound extra. In drums any quantity one-fourth cent per pound extra.

The new prices came as a surprise to the trade and on the whole every one with the possible exception of the consumers is very unfavorably disposed to the new schedule. Some acid manufacturers, whose equipment was not up to the latest specifications, found considerable difficulty in producing and making a fair profit under the previously fixed prices and it looks as though some of these plants will be compelled to suspend operations or in the event of the government insisting upon a production it will of course be necessary to obtain financial assistance from the War department. It is reported that one plant whose equipment was rather worn intended suspending operations after present raw materials were consumed but the government has the matter under reconsideration and it is believed that the plant will continue operations.

**Nitrate of Soda:**—The Chemical Alliance makes the following announcement: "We must again impress upon fertilizer manufacturers, particularly those operating sulphuric acid plants, the necessity for the conservation of their stocks of nitrate of soda. The mere fact that a company may have a liberal stock of nitrate of soda on hand should not be considered as an unlimited license to use it in mixtures or otherwise dispose of it. On account of the needs of the Government in its war program, very little encouragement is held out for any supplies of nitrate of soda for fertilizer manufacturers for spring use."

**Bicarbonate of Soda:**—No immediate relief is offered in the position of this item which continues to be in rather scant supply. The prices are firm and sales are passing at \$3.45 in carload lots. Offerings which appear on the market are readily bought up and quotations for October and November deliveries range from \$3.30 to \$3.40. Efforts on the part of buyers to cover at \$3.25 in New York were unsuccessful.

**Bichromate of Soda:**—Interests now concede that the position of this material is weakening and the cheap offerings which are placed on the market seemingly originate no activity. Sales that are consummated are closed on some low levels and prices now generally range from 23c. to 24c.

**Oxalic Acid:**—Trading is of a routine nature and the product on the whole is not in pronounced demand. Offerings which appear on the market seemingly constitute the only activity and prices range from 40c. to 42c.



## General Chemicals

WHOLESALE PRICES IN NEW YORK MARKET, SEPT. 24, 1918

|                                                         |      |               |         |
|---------------------------------------------------------|------|---------------|---------|
| Acetic anhydride.....                                   | lb.  | 1.60          | 1.85    |
| Acetone.....                                            | lb.  | 2.54          | 2.52    |
| Acetic acid, 28 per cent.....                           | cwt. | 5.96          | 6.11    |
| Acetic, 56 per cent.....                                | cwt. | 10.76         | 10.87   |
| Acetic, glacial, 99 1/2 per cent, carbonyl.....         | cwt. | 19.00         | 19.20   |
| Boric crystals.....                                     | lb.  | 1.13          | .15     |
| Calcium crystals.....                                   | lb.  | .82           | Nominal |
| Hydrochloric, C. P.....                                 | lb.  | .08           | .08 1/2 |
| Hydrofluoric, 30 per cent in barrels.....               | lb.  | .15           | .16     |
| Lactic, 44 per cent.....                                | lb.  | .15           | .16     |
| Lactic, 52 per cent.....                                | lb.  | .15           | .16     |
| Molybdenum, C. P.....                                   | lb.  | 6.90          | 7.40    |
| Nitric, 36 deg.....                                     | lb.  | .09 1/2       | Nominal |
| Nitric, 42 deg.....                                     | lb.  | .09 1/2       | .10     |
| Oxalic, crystals.....                                   | lb.  | .07 1/2       | .10     |
| Phosphoric, 47-50 per cent paste.....                   | lb.  | .33           | .40     |
| Phosphoric, rel. 50 per cent.....                       | lb.  | .25           | .35     |
| Picric.....                                             | lb.  | 3.25          | 3.50    |
| Pyrogallol, resublimed.....                             | ton  | 18.00         | .00     |
| Sulphuric, 60 deg.....                                  | ton  | 28.00         | .00     |
| Sulphuric, 66 deg.....                                  | ton  | 60.00         | 65.00   |
| Sulphuric, oleum (Fuming), tank cars.....               | ton  | 1.40          | 1.30    |
| Tannic, U. S. P., bulk.....                             | lb.  | .86           | .95     |
| Tartaric, crystals.....                                 | lb.  | 1.70          | 1.75    |
| Tungstic, per lb. of W.....                             | gal. | 4             | .00     |
| Alcohol, sugar case, 183 proof.....                     | gal. | 91 1/2        | .92     |
| Alcohol, wood, 95 per cent.....                         | gal. | .69           | .69     |
| Alcohol, dehydrated, 180 proof.....                     | gal. | .69           | .69     |
| Alum, ammonia lump.....                                 | lb.  | .06           | .06 1/2 |
| Alum, chrome ammonium.....                              | lb.  | .18           | .20     |
| Alum, chrome potassium.....                             | lb.  | .20           | .22     |
| Alum, chrome sodium.....                                | lb.  | .12 1/2       | .13     |
| Alum, potash lump.....                                  | lb.  | .07 1/2       | .10     |
| Aluminium sulphate, technical.....                      | lb.  | .07 1/2       | .07 1/2 |
| Aluminium sulphate, iron free.....                      | lb.  | .03 1/2       | .04     |
| Ammonia aqua, 26 deg., carbonyl.....                    | lb.  | .08 1/2       | .09     |
| Ammonia, anhydrous.....                                 | lb.  | .12           | Nominal |
| Ammonium carbonate.....                                 | lb.  | .12           | .13     |
| Ammonium nitrate.....                                   | lb.  | (Fixed Price) | .15     |
| Ammonium sulphate domestic.....                         | lb.  | .07 1/2       | .08     |
| Amplac, white.....                                      | gal. | 5.30          | 5.35    |
| Arsenic, white.....                                     | lb.  | .09 1/2       | .13     |
| Arsenic, red.....                                       | lb.  | .65           | .70     |
| Barium carbonate, 99 per cent.....                      | ton  | 80.00         | 90.00   |
| Barium chloride, 97-98 per cent.....                    | ton  | 65.00         | 67.00   |
| Barium chloride.....                                    | ton  | 70.00         | 80.00   |
| Barium sulphate (Blanc Fixe, Dry).....                  | lb.  | .04 1/2       | .05     |
| Barium nitrate.....                                     | lb.  | .12           | .14     |
| Barium peroxide, basis 70 per cent.....                 | lb.  | .08           | .09     |
| Bleaching powder, 35 per cent chlorine.....             | lb.  | .05           | .05 1/2 |
| Borax, crystals, sacks.....                             | lb.  | .08 1/2       | .08 1/2 |
| Bromine, crude.....                                     | ton  | 65.00         | 70.00   |
| Bromine, technical.....                                 | lb.  | .07 1/2       | .08     |
| Calcium, acetate, crude.....                            | lb.  | .04           | .05     |
| Calcium, carbide.....                                   | lb.  | .10           | .10     |
| Calcium chloride, 70-75 per cent, fused, lump.....      | ton  | 22.00         | 24.00   |
| Calcium peroxide.....                                   | lb.  | .22           | .23     |
| Calcium phosphate.....                                  | lb.  | .09           | .09 1/2 |
| Calcium sulphate-98-99 per cent.....                    | lb.  | .08           | .09     |
| Carbon bisulphide, drums.....                           | lb.  | .08           | .09     |
| Carbon tetrachloride, drums.....                        | lb.  | .08           | .09     |
| Carbonyl chloride (phosgene).....                       | lb.  | 1.10          | 1.50    |
| Caustic potash, 88-92 per cent.....                     | lb.  | .45           | .77     |
| Caustic soda, 48 per cent.....                          | 100  | 4.25          | 4.40    |
| Chlorine, liquid (Government Purchase).....             | 100  | (Fixed Price) | .07 1/2 |
| Cobalt oxide.....                                       | lb.  | 1.60          | 1.65    |
| Coppers.....                                            | lb.  | .02 1/2       | .02 1/2 |
| Copper carbonate.....                                   | lb.  | .35           | .37     |
| Copper cyanide.....                                     | lb.  | .75           | .78     |
| Copper sulphate, 99 per cent, large crystals.....       | lb.  | .09 1/2       | .09 1/2 |
| Cream of tartar, crystals.....                          | lb.  | .80           | .85     |
| Epsom salt, heavy, U. S. P.....                         | 100  | 3.80          | 3.90    |
| Formaldehyde, 40 per cent.....                          | lb.  | .16 1/2       | .17     |
| Glauber's salt.....                                     | lb.  | .02 1/2       | .03     |
| Glycerine, bulk, C. P.....                              | lb.  | .63           | .65     |
| Iodine, resublimed.....                                 | lb.  | 4.25          | 4.30    |
| Iron oxide.....                                         | lb.  | .13           | .15     |
| Lead acetate, white crystals.....                       | lb.  | .17           | .17 1/2 |
| Lead arsenate (Paste).....                              | lb.  | .15           | .15     |
| Lead nitrate.....                                       | lb.  | Nominal       | .15     |
| Litharge, American.....                                 | lb.  | .12           | .14     |
| Lithium carbonate.....                                  | lb.  | 1.50          | 2.05    |
| Magnesium carbonate, technical.....                     | lb.  | .16           | .17     |
| Nickel salt, single.....                                | lb.  | .14           | .15     |
| Nickel salt, double.....                                | lb.  | .12           | .13     |
| Phosgene, (see Carbonyl chloride).....                  | lb.  | 1.10          | 1.50    |
| Phosphorus, red.....                                    | lb.  | 1.05          | 1.10    |
| Phosphorus, yellow.....                                 | lb.  | 1.10          | 1.20    |
| Potassium bichromate.....                               | lb.  | .45           | .46     |
| Potassium bromide granular.....                         | lb.  | .25           | 1.26    |
| Potassium carbonate, calcined, 85-90 per cent.....      | lb.  | .38           | .40     |
| Potassium chlorate, crystals.....                       | lb.  | .38           | .40     |
| Potassium cyanide, 98-99 per cent.....                  | lb.  | .60           | .70     |
| Potassium iodide.....                                   | lb.  | .75           | .80     |
| Potassium muric acid, 80-85 p. c. basis of 80 p. c..... | ton  | 300.00        | 350.00  |
| Potassium nitrate.....                                  | lb.  | .27           | .31     |
| Potassium permanganate U. S. P.....                     | lb.  | 1.85          | 2.00    |
| Potassium persulfate, red.....                          | lb.  | 2.25          | 2.50    |
| Potassium prussiate, yellow.....                        | lb.  | 1.00          | 1.10    |
| Potassium sulphate, 90-95 p. c. basis 90 p. c.....      | ton  | Nominal       | .14     |
| Rochelle salts.....                                     | lb.  | .42           | .48     |
| Salammoniac, gray gran.....                             | lb.  | .19           | .20     |
| Salammoniac, white gran.....                            | lb.  | 1.40          | 1.65    |
| Salt cake.....                                          | ton  | 22.50         | 25.00   |
| Silver cyanide, based on market price of silver.....    | oz.  | .63 1/2       | .64     |
| Silver nitrate.....                                     | lb.  | .63 1/2       | .64     |
| Soda ash, 58 per cent, light, flat (bags).....          | 100  | 2.60          | .00     |
| Soda ash, 58 per cent, dense, flat.....                 | 100  | 3.75          | 3.80    |
| Sodium acetate.....                                     | lb.  | Nominal       | .04 1/2 |
| Sodium bicarbonate, domestic.....                       | lb.  | .03 1/2       | .04 1/2 |
| Sodium bicarbonate, English.....                        | lb.  | .23 1/2       | .24     |
| Sodium bichromate.....                                  | lb.  | .25           | .27     |
| Sodium bisulphite, powd.....                            | lb.  | .12           | .14     |
| Sodium chlorate.....                                    | lb.  | .25           | .25 1/2 |
| Sodium cyanide.....                                     | lb.  | .30           | .35     |
| Sodium fluoride, commercial.....                        | lb.  | .17           | .18     |

|                                             |     |         |         |
|---------------------------------------------|-----|---------|---------|
| Sodium hyposulphite.....                    | lb. | 2.80    | 3.00    |
| Sodium molybdate, per lb. of Mo.....        | lb. | 2.50    | .00     |
| Sodium nitrate.....                         | 100 | 4.12    | 5.00    |
| Sodium peroxide.....                        | lb. | .35     | .45     |
| Sodium phosphate.....                       | lb. | .04     | .04 1/2 |
| Sodium prussiate, yellow.....               | lb. | .39     | .40     |
| Sodium silicate, liquid (60 deg).....       | lb. | .03     | .04     |
| Sodium sulphate, 30 per cent, crystals..... | lb. | .07 1/2 | .08 1/2 |
| Sodium sulphate, 60 per cent, fused.....    | 100 | 1.05    | 1.15    |
| Sodium sulphate.....                        | lb. | .05 1/2 | .06     |
| Strontium nitrate.....                      | lb. | .25     | .30     |
| Sulphur chloride, drums.....                | lb. | .07 1/2 | .09     |
| Sulphur dioxide, liquid, in cylinders.....  | lb. | .15     | .40     |
| Sulphur, flowers, sublimed.....             | 100 | 4.39    | 4.50    |
| Sulphur, roll.....                          | 100 | 3.70    | 3.85    |
| Sulphur, crude.....                         | ton | 65.00   | 70.00   |
| Tin bichloride, 30 deg.....                 | lb. | .28     | .29     |
| Tin oxide.....                              | lb. | .18     | .20     |
| Zinc carbonate.....                         | lb. | .15     | .15 1/2 |
| Zinc chloride.....                          | lb. | .15     | .15 1/2 |
| Zinc cyanide.....                           | lb. | .13 1/2 | .14     |
| Zinc dust, 350 mesh.....                    | lb. | .12 1/2 | .14     |
| Zinc oxide, American process XX.....        | lb. | .12 1/2 | .14     |
| Zinc sulphate.....                          | lb. | .12 1/2 | .06 1/2 |

## Coal Tar Products (Crude)

|                                             |      |               |       |
|---------------------------------------------|------|---------------|-------|
| Benzol, pure, water white.....              | gal. | .23           | .28   |
| Benzol, 90 per cent.....                    | gal. | .25           | .25   |
| Toluol, in tank cars.....                   | gal. | (Fixed Price) | 1.50  |
| Toluol, for non-military use, in drums..... | gal. | (Fixed Price) | 1.55  |
| Xylol, pure, water white.....               | gal. | .45           | .45   |
| Solvent naphtha, water white.....           | gal. | .18           | .25   |
| Solvent naphtha, crude, heavy.....          | gal. | .12           | .15   |
| Cresol oil, 25 per cent.....                | gal. | .30           | .32   |
| Dip oil, 20 per cent.....                   | gal. | .30           | .32   |
| Pitch, various grades.....                  | ton  | 8.00          | 20.00 |
| Carbolic acid, crude, 95-97 per cent.....   | lb.  | 1.05          | 1.10  |
| Carbolic acid, crude, 50 per cent.....      | lb.  | .75           | .85   |
| Carbolic acid, crude, 25 per cent.....      | lb.  | .35           | .38   |
| Cresol, U. S. P.....                        | lb.  | .19           | .20   |

## Intermediates, Etc.

|                                    |     |         |         |
|------------------------------------|-----|---------|---------|
| Alpha naphthol, crude.....         | lb. | 1.00    | 1.10    |
| Alpha naphthol, refined.....       | lb. | 1.50    | 1.60    |
| Alpha naphthylamine.....           | lb. | .55     | .60     |
| Aniline, for drum extra.....       | lb. | .30     | .32     |
| Aniline salts.....                 | lb. | .44     | .45     |
| Anthracene, 80 per cent.....       | lb. | Nominal | .00     |
| Benzaldehyde (f.f.c.).....         | lb. | 4.25    | 4.50    |
| Benzidine, base.....               | lb. | 1.75    | .85     |
| Benzidine, sulphate.....           | lb. | 4.00    | 4.45    |
| Benzoic acid (U. S. P).....        | lb. | 2.90    | 3.00    |
| Benzoate of Soda, U. S. P.....     | lb. | 2.75    | 2.95    |
| Benzyl chloride.....               | lb. | 2.45    | 4.50    |
| Beta naphthol benzoate.....        | lb. | 10.00   | 12.00   |
| Beta naphthol, sublimed.....       | lb. | .75     | .85     |
| Beta naphthylamine, sublimed.....  | lb. | 2.65    | .15     |
| Dichlorobenzol.....                | lb. | 4.00    | 4.50    |
| Diethylaniline.....                | lb. | 4.00    | 4.50    |
| Dinitro benzol.....                | lb. | .36     | .38     |
| Dinitrochlorobenzol.....           | lb. | .40     | .45     |
| Dinitronaphthalene.....            | lb. | .45     | .50     |
| Dinitrophenol.....                 | lb. | .65     | .75     |
| Dinitrophenol.....                 | lb. | .65     | .75     |
| Dimethylaniline.....               | lb. | .55     | .76     |
| Diphenylamine.....                 | lb. | 1.00    | 1.10    |
| H-acid.....                        | lb. | 3.25    | 3.50    |
| Metaphenylenediamine.....          | lb. | 1.85    | 2.05    |
| Monochlorobenzol.....              | lb. | .17     | .20 1/2 |
| Naphthalene, flake.....            | lb. | .09     | .09     |
| Naphthalene, balls.....            | lb. | .11     | .12 1/2 |
| Naphthionic acid, crude.....       | lb. | 1.20    | 1.30    |
| Naphthylamine, sulphonic acid..... | lb. | 1.00    | 1.10    |
| Nitro naphthalene.....             | lb. | .45     | .50     |
| Nitro toluol.....                  | lb. | .55     | .60     |
| Ortho-amidophenol.....             | lb. | .15     | .20     |
| Ortho-dichlorobenzol.....          | lb. | 1.00    | 1.10    |
| Ortho-nitro-toluol.....            | lb. | .75     | .85     |
| Para-amidophenol, base.....        | lb. | 4.25    | 4.50    |
| Para-amido-phenol, H. Cl.....      | lb. | 4.25    | 5.00    |
| Para-dichlorobenzol.....           | lb. | .15     | .20     |
| Paranitraniline.....               | lb. | .80     | 1.95    |
| Para-nitro-toluol.....             | lb. | 1.00    | 1.60    |
| Paraphenylenediamine.....          | lb. | 4.00    | 4.10    |
| Para toluidine.....                | lb. | 2.25    | 2.50    |
| Phthalic acid anhydride.....       | lb. | 4.00    | 4.50    |
| Phenol, U. S. P.....               | lb. | 1.15    | 1.20    |
| Reagent, technical.....            | lb. | 4.50    | 5.00    |
| Reagent, pure.....                 | lb. | 7.50    | 8.00    |
| S-hyvic acid.....                  | lb. | .85     | .95     |
| Sesol.....                         | lb. | .50     | .50     |
| Sulphanilic acid, crude.....       | lb. | .31     | .33     |
| Tolidin.....                       | lb. | 2.50    | 3.00    |
| Tolidine-mixture.....              | lb. | .85     | .90     |

## Petroleum Oils

Crude (at the Wells)

|                            |      |         |       |
|----------------------------|------|---------|-------|
| Pennsylvania.....          | bbl. | 4.00    | ..... |
| Cornish, Ohio.....         | bbl. | 2.80    | ..... |
| Somerset, Ky.....          | bbl. | 2.60    | ..... |
| Worster, Ohio.....         | bbl. | 2.68    | ..... |
| Indiana.....               | bbl. | 2.28    | ..... |
| Illinois.....              | bbl. | 2.25    | ..... |
| Oklahoma and Kansas.....   | bbl. | 2.25    | ..... |
| Caddo, La., light.....     | bbl. | 2.25    | ..... |
| Corrigan, Tex., light..... | bbl. | 2.25    | ..... |
| California.....            | bbl. | 1.35    | 1.57  |
| Gulf Coast.....            | bbl. | 1.30    | ..... |
| Mexican.....               | bbl. | 1.90    | ..... |
| Fuel Oil                   |      |         |       |
| New York.....              | gal. | .15     | ..... |
| Philadelphia.....          | gal. | .10 1/2 | 1.57  |
| Baltimore.....             | gal. | .07 1/2 | ..... |
| Pittsburgh.....            | gal. | .07 1/2 | ..... |
| Texas.....                 | bbl. | 1.85    | 2.35  |
| Los Angeles.....           | bbl. | 1.65    | ..... |

## Gasoline (Wholesale)

|                           |      |        |   |        |
|---------------------------|------|--------|---|--------|
| New York, motor.....      | gal. | 24 1/2 | — | —      |
| Gas machine.....          | gal. | 41 1/2 | — | —      |
| 7-16 degrees.....         | gal. | 31 1/2 | — | 39 1/2 |
| 70-72 degrees.....        | gal. | 32 1/2 | — | 37 1/2 |
| 67-70 degrees.....        | gal. | 30 1/2 | — | 36 1/2 |
| Pittsburgh, motor.....    | gal. | 22 1/2 | — | 23     |
| Chicago, motor.....       | gal. | 21 1/2 | — | 22     |
| Oklahoma, motor.....      | gal. | 21 1/2 | — | 22     |
| San Francisco, motor..... | gal. | 20 1/2 | — | 21 1/2 |

## Paraffine Waxes

|                                  |     |        |   |        |
|----------------------------------|-----|--------|---|--------|
| Crude, 103 to 105 deg. m.pt..... | lb. | 08 1/2 | — | 09     |
| Crude, 118 to 120 deg. m.pt..... | lb. | 09 1/2 | — | 10     |
| Crude, 124 to 126 deg. m.pt..... | lb. | 10     | — | 11     |
| Refined, 120 deg. m.pt.....      | lb. | 13 1/2 | — | 14     |
| Refined, 126 deg. m.pt.....      | lb. | 14     | — | 15     |
| Refined, 135 deg. m.pt.....      | lb. | 16     | — | 16 1/2 |
| Ozokerite, brown.....            | lb. | 75     | — | 80     |
| Ozokerite, green.....            | lb. | 85     | — | 90     |

## Lubricants

|                                                  |      |    |   |    |
|--------------------------------------------------|------|----|---|----|
| Black, reduced, 29 gravity, 25-30 cold test..... | gal. | 24 | — | 25 |
| Cylinder, light.....                             | gal. | 39 | — | 50 |
| Cylinder, dark.....                              | gal. | 39 | — | 43 |
| Paraffine, high viscosity.....                   | gal. | 40 | — | 41 |
| Paraffine, 901 sp. gr.....                       | gal. | 36 | — | 38 |
| Paraffine, .885 sp. gr.....                      | gal. | 26 | — | 28 |

## Flotation Oils

(Prices at New York unless otherwise stated)

|                                                                          |      |    |   |    |
|--------------------------------------------------------------------------|------|----|---|----|
| Pine oil, crude, f. o. b. Florida.....                                   | gal. | 44 | — | 46 |
| Pine oil, steam-distilled, sp. gr. 0.925-0.940.....                      | gal. | 58 | — | 60 |
| Pine oil, destructively distilled.....                                   | gal. | 58 | — | 60 |
| Pine tar oil, sp. gr. 1.07-1.035.....                                    | gal. | 35 | — | 36 |
| Pine tar oil, double refined, sp. gr. 0.965-0.990.....                   | gal. | 42 | — | 43 |
| Pine tar oil, ref., light, sp. gr. 0.950, tank cars, f. o. b. works..... | gal. | 37 | — | 38 |
| Pine tar oil, ref., heavy, sp. gr. 1.025, tank cars, f. o. b. works..... | gal. | 28 | — | 29 |
| Pine tar oil, ref., thin, sp. gr. 1.060-1.080.....                       | gal. | 52 | — | 53 |
| Turpentine, crude, sp. gr. 0.870-0.900.....                              | gal. | 45 | — | 46 |
| Hardwood oil, f. o. b. Michigan, sp. gr. 0.960-0.990.....                | gal. | 23 | — | 24 |
| Hardwood oil, f. o. b. Michigan, sp. gr. 1.00-1.08.....                  | gal. | 23 | — | 24 |
| Wood creosote, ref. f. o. b. Florida.....                                | gal. | 31 | — | 32 |

## Naval Stores

|                                               |           |       |   |       |
|-----------------------------------------------|-----------|-------|---|-------|
| Rosin A-E barrel.....                         | 280 lb.   | 15.65 | — | 15.55 |
| Rosin F-I.....                                | 280 lb.   | 15.55 | — | 16.00 |
| Rosin K-N.....                                | 280 lb.   | 16.00 | — | 16.75 |
| Rosin W-G-V.....                              | 280 lb.   | 17.00 | — | 17.75 |
| Spirits of turpentine.....                    | gal.      | 67    | — | 68    |
| Wood turpentine, steam distilled.....         | gal.      | 63    | — | 64    |
| Wood turpentine, destructively distilled..... | gal.      | 78    | — | 79    |
| Pitch.....                                    | bbbl. 200 | 13.00 | — | 13.50 |
| Tar, kiln dried.....                          | 280 lb.   | 14.00 | — | 14.50 |
| Retort tar.....                               | 280 lb.   | 74    | — | 75    |
| Rosin oil, first run.....                     | gal.      | 77    | — | 78    |
| Second run.....                               | gal.      | 82    | — | 83    |
| Fourth run.....                               | gal.      | 92    | — | 93    |

## Vegetable Oils

|                               |      |      |   |      |
|-------------------------------|------|------|---|------|
| Castor oil.....               | lb.  | 34   | — | 38   |
| China wood oil.....           | lb.  | 30   | — | 31   |
| Coconut oil.....              | lb.  | 17   | — | 22   |
| Corn oil.....                 | lb.  | 18   | — | 22   |
| Cottonseed oil, crude.....    | gal. | 20   | — | 22   |
| Lined oil, raw, cars.....     | gal. | 1.81 | — | 1.86 |
| Olive oil.....                | gal. | 4.25 | — | 4.50 |
| Peanut oil, crude.....        | lb.  | 18   | — | 22   |
| Soya bean oil, Manchuria..... | lb.  | 17   | — | 1.83 |

## Glues

|                                 |      |      |   |      |
|---------------------------------|------|------|---|------|
| Extra white.....                | lb.  | 36   | — | 45   |
| Cabinet.....                    | lb.  | 31   | — | 40   |
| Brown foot stock.....           | lb.  | 18   | — | 22   |
| Fish glue, 50-gal. barrels..... | gal. | 1.00 | — | 1.80 |

## Miscellaneous Materials

|                                         |           |        |   |        |
|-----------------------------------------|-----------|--------|---|--------|
| Barytes, floated, white, foreign.....   | ton       | 38.00  | — | 42.00  |
| Barytes, floated, white, domestic.....  | ton       | 33.00  | — | 36.00  |
| Beeswax, white, pure.....               | lb.       | 63     | — | 65     |
| Beeswax, unbleached.....                | lb.       | 43     | — | 48     |
| Blanc fixe.....                         | lb.       | 05 1/2 | — | 06     |
| Casein.....                             | lb.       | 17 1/2 | — | 20     |
| Japan graphite.....                     | lb.       | 07 1/2 | — | 25     |
| Chalk, light, precipitated, Englab..... | lb.       | 04     | — | 08     |
| China clay, imported, lump.....         | ton       | 20.00  | — | 40.00  |
| China clay, domestic, lump.....         | ton       | 15.00  | — | 22.50  |
| Fluorapatite.....                       | ton       | 8.00   | — | 12.00  |
| Fluorspar, gravel, f. o. b. mines.....  | ton       | 28.00  | — | 40.00  |
| Fluorspar, washed, powdered.....        | ton       | 90.00  | — | 100.00 |
| Fuller's earth, powdered.....           | 100 lb.   | 1.50   | — | 2.00   |
| Japan wax.....                          | lb.       | 26     | — | 27     |
| Mexican graphite.....                   | 75.00 lb. | 75.00  | — | 100.00 |
| Madagascar graphite.....                | lb.       | 10     | — | 15     |
| Orange shellac.....                     | lb.       | 72     | — | 78     |
| Red lead, dry, carloads.....            | 100 lb.   | 04     | — | 08     |
| Soapstone.....                          | ton       | 15.00  | — | 25.00  |
| Stearic acid, 120 deg. m.pt.....        | lb.       | 15     | — | 16     |
| Stearic acid, 140 deg. m.pt.....        | lb.       | 15     | — | 16     |
| Talc, American, white.....              | 20.00 lb. | 40.00  | — | 40.00  |
| White lead, dry.....                    | lb.       | 09 1/2 | — | 10 1/2 |

## Refractories, Etc.

(F. O. B. Works)

|                                       |          |        |   |        |
|---------------------------------------|----------|--------|---|--------|
| Chrome brick.....                     | net ton  | 175.00 | — | —      |
| Chrome cement.....                    | net ton  | 75.00  | — | —      |
| Clay brick, 1st quality fireclay..... | per 1000 | 50.00  | — | 55.00  |
| Clay brick, second quality.....       | per 1000 | 35.00  | — | 40.00  |
| Magnetite, raw.....                   | ton      | 30.00  | — | 35.00  |
| Magnetite, calcined, powdered.....    | ton      | 50.00  | — | 65.00  |
| Magnetite, dead burned.....           | net ton  | 110.00 | — | 125.00 |
| Silica brick.....                     | per 1000 | 50.00  | — | 60.00  |

## Ferroalloys

|                                                                          |     |        |   |        |
|--------------------------------------------------------------------------|-----|--------|---|--------|
| Ferrocobalt, 15-18 per cent, carloads, f. o. b. Niagara Falls, N. Y..... | ton | 200.00 | — | 250.00 |
| Ferrocobalt.....                                                         | ton | 15.00  | — | 30.00  |
| Ferromanganese, per lb. of Cr.....                                       | lb. | 30     | — | 40     |
| Ferromanganese, domestic, 70 per cent basis.....                         | ton | 250.00 | — | —      |
| Ferromanganese, English.....                                             | ton | 325.00 | — | —      |
| Singoleisen (16-18).....                                                 | ton | 75.00  | — | —      |
| Ferromolybdenum, per lb. of Mo.....                                      | lb. | 4.00   | — | 4.50   |
| Ferrosilicon, 75 per cent, f. o. b. N. Y.....                            | ton | 153.00 | — | 160.00 |
| Ferrosilicon, 50 per cent, contract, f. o. b. Pittsburgh.....            | ton | 2.25   | — | 2.40   |
| Ferrotungsten, 75-85 per cent, f. o. b. Pittsburgh.....                  | lb. | 7.50   | — | —      |
| Ferrotungsten, f. o. b. works, per lb. of U.....                         | lb. | 7.50   | — | —      |
| Ferrovandium, f. o. b. works.....                                        | lb. | 17     | — | 20     |

## Ores and Semi-finished Products

|                                                              |      |       |   |        |
|--------------------------------------------------------------|------|-------|---|--------|
| Chrome ore, 45 per cent minimum, f. o. b. Cal. per unit..... | ton  | 1.50  | — | 1.55   |
| Chrome ore, 45 per cent and over, New York, per unit.....    | ton  | 1.40  | — | —      |
| Coke.....                                                    | ton  | 6.00  | — | 7.00   |
| Manganese ore, 48 per cent and over, per unit.....           | ton  | 1.20  | — | —      |
| Manganese ore, chemical.....                                 | ton  | 80.00 | — | 100.00 |
| Molybdenite, per lb. of MoS <sub>2</sub> .....               | lb.  | 1.25  | — | 1.50   |
| Tungsten, Scheelite, per unit of WO <sub>3</sub> .....       | ton  | 25.00 | — | —      |
| Tungsten, Wolframite, per unit of WO <sub>3</sub> .....      | ton  | 24.00 | — | —      |
| Uranium oxide, 96%.....                                      | lb.  | 3.25  | — | 3.60   |
| Vanadium pentoxide, 99%.....                                 | lb.  | 10.50 | — | —      |
| Pyrite, foreign.....                                         | unit | 17    | — | 27     |
| Pyrite, domestic.....                                        | unit | 28    | — | 30 1/2 |

## Plant Supplies

## BUILDING MATERIALS

|                                             |         |        |   |        |
|---------------------------------------------|---------|--------|---|--------|
| Common clay bricks.....                     | N       | 13.00  | — | 14.00  |
| Hollow tile, 4 x 12 x 12.....               | M       | 60.00  | — | —      |
| Hollow tile, 12 x 12 x 12.....              | M       | 170.00 | — | —      |
| Lime.....                                   | ton     | 16.00  | — | —      |
| Portland cement.....                        | bbbl.   | 2.59   | — | —      |
| Single glass (8-16), 10 x 26-16 x 24.....   | M       | 21.00  | — | 27.00  |
| Double glass (16-16), 10 x 26-16 x 29.....  | M       | 31.00  | — | 39.00  |
| Extra pine lumber.....                      | M       | 39.00  | — | 45.00  |
| Fir lumber.....                             | M       | 38.00  | — | 53.00  |
| Hemlock.....                                | M       | 24.50  | — | 40.00  |
| Thinned felt (14-lb. sq.).....              | ton     | 68.00  | — | —      |
| Roofing pitch.....                          | ton     | 27.00  | — | —      |
| Asphalt coated roofing (35-55-lb. sq.)..... | ton     | 1.60   | — | 2.45   |
| State surfaced asphalt shingles.....        | sq.     | 5.25   | — | 5.50   |
| Corrugated galvanized iron.....             | ton     | 109.00 | — | 127.00 |
| Putty.....                                  | 100 lb. | 6.75   | — | —      |
| Red oxide (Ppte. Coppere).....              | ton     | 15.00  | — | 20.00  |
| Native red oxide.....                       | 100 lb. | 3.25   | — | 8.00   |
| Red metallic paint.....                     | 100 lb. | 1.20   | — | 1.50   |
| White lead in oil.....                      | 100 lb. | 11.80  | — | 14.00  |
| Red lead in oil.....                        | 100 lb. | 12.28  | — | 14.27  |
| Zinc oxide (dry).....                       | 100 lb. | 13.00  | — | 14.50  |
| Zinc oxide—leaded.....                      | 100 lb. | 9.00   | — | 10.00  |
| Yellow ochre.....                           | 100 lb. | 1.50   | — | 10.00  |
| Ultra marine blue.....                      | 100 lb. | 14.00  | — | 50.00  |
| Prussian blue.....                          | 100 lb. | 135.00 | — | 150.00 |
| Chrome green.....                           | 100 lb. | 40.00  | — | 70.00  |
| Paris green.....                            | 100 lb. | 43.00  | — | 49.00  |
| Mineral black.....                          | 100 lb. | 6.00   | — | 2.25   |
| Powdered bone black.....                    | 100 lb. | 5.50   | — | 12.00  |
| Lampblack.....                              | 100 lb. | 15.00  | — | 45.00  |
| Gas carbon.....                             | 100 lb. | 16.00  | — | 25.00  |
| Mexican petroleum pitch.....                | 100 lb. | 1.00   | — | 2.00   |
| Gilaonite.....                              | 100 lb. | 2.00   | — | 2.50   |
| Coal tar pitch.....                         | 100 lb. | .40    | — | 1.00   |

## STRUCTURAL IRON

|                                        |     |        |   |        |
|----------------------------------------|-----|--------|---|--------|
| Blue annealed sheet iron.....          | ton | 84.00  | — | 89.00  |
| Black sheet iron.....                  | ton | 96.00  | — | 104.00 |
| Galvanized iron.....                   | ton | 105.00 | — | 135.00 |
| Tern plate, 8-lb. coating.....         | ton | 150.00 | — | —      |
| Tern plate, 15-lb. coating.....        | ton | 172.50 | — | —      |
| Tern plate, 25-lb. coating.....        | ton | 200.00 | — | —      |
| Tern plate, 40-lb. coating.....        | ton | 240.00 | — | —      |
| Tio plate, prime.....                  | ton | 155.00 | — | —      |
| Tank plates.....                       | ton | 65.00  | — | 70.00  |
| Beams, channels, angles, T's, Z's..... | ton | 60.00  | — | 65.00  |
| Rivets.....                            | ton | 88.00  | — | 92.00  |
| Steel pipe, 1 to 3-inch.....           | ton | 51.00  | — | —      |
| Bar iron and steel.....                | ton | 172.50 | — | 70.00  |
| Chain (1 inch proof coil).....         | ton | 150.00 | — | —      |
| Nails, bolts, nuts, washers.....       | ton | 70.00  | — | 80.00  |
| Tool steels, special alloys.....       | ton | 300.00 | — | 500.00 |
| Bessemer pig iron.....                 | ton | 17.50  | — | —      |
| Bessemer steel.....                    | ton | 47.50  | — | —      |
| No. 2 foundry.....                     | ton | 37.90  | — | —      |
| Steel billets (4 x 4).....             | ton | 47.50  | — | —      |

## POWER HOUSE SUPPLIES

|                                 |     |         |   |      |
|---------------------------------|-----|---------|---|------|
| Steam packing, rubber duck..... | lb. | .99     | — | 1.10 |
| Asbestos, high pressure.....    | lb. | 1.76    | — | —    |
| Asbestos, wired.....            | lb. | 1.30    | — | —    |
| Asbestos, graphited braid.....  | lb. | 1.25    | — | —    |
| Asbestos, wick.....             | lb. | .75     | — | —    |
| Rubber, sheet.....              | lb. | .66     | — | —    |
| Cup grease.....                 | lb. | .07     | — | —    |
| Transmission grease.....        | lb. | .12     | — | —    |
| Axle grease.....                | lb. | .04     | — | —    |
| Gear grease.....                | lb. | .04     | — | —    |
| Cotton waste.....               | lb. | .08 1/2 | — | .13  |
| Hose, American, 2 1/2 in.....   | ft. | .75     | — | —    |
| Hose, air, 3 in.....            | ft. | .50     | — | .60  |

# INDUSTRIAL NEWS

## Plant Construction—Catalogs—New Publications

### Construction and Operation

#### Alabama

**NORTH BIRMINGHAM**—The Aetna Powder Co. will rebuild its plant recently destroyed by fire.

**SHEFFIELD**—The Sheffield Co. will build a filtration plant. Walter G. Kirkpatrick, Box 285, consulting engineer.

**SPRINGFORD**—The State Civil Department, Montgomery, will build water system; plans include the erection of a filtration plant and water mains here. Estimated cost, \$4,000. Sanitary Engineer Hazlehurst of the State Board of Health, Montgomery, in charge.

**TROY**—The Standard Chemical & Oil Co. will rebuild mill No. 2 recently destroyed by fire entailing a loss of \$60,000.

#### Arizona

**DOUGLAS**—The Empire Smelting & Refining Co. has applied to the city for a site for the erection of a smelter. Estimated cost, \$100,000. L. C. Barlow, manager.

#### Arkansas

**BATESVILLE**—The Blue Pig Mining Co. is in the market for a log washer for manganese and steam shovel engine, boiler, lumber, roofing, concrete, pump and pipe. Estimated cost, \$25,000. A. Besse, superintendent.

#### California

**MARE ISLAND** (Vallejo, P. O.)—The Bureau of Yards & Docks, Navy Department, Wash., D. C., plans to build an oxyacetylene generating plant here.

**SANTA BARBARA**—Winsor Soule, architect, 1206 E. St., is preparing plans for the construction of a 40 x 103 ft. reinforced-concrete laboratory building which will be donated to the Cottage Hospital Association.

**VICTORVILLE**—The United Tunstun-Copper Mines will build a mill at Piedmont in the Morongo District. Frank F. Peard, 30 Broad St., New York City, N. Y., president.

#### Georgia

**BRUNSWICK**—The Atlantic Refining Co., 314 E. Frank Ave., Philadelphia, Pa., will build an oil refinery here.

#### Illinois

**CHICAGO**—Swift & Co., 76 West Monroe St., will build a two-story, 15 x 50 ft. fatty acid building. Estimated cost, \$3,000.

**CHICAGO**—Wilson & Co., 41st and Ashland Ave. will build a three-story, 20 x 34 ft. fertilizer, dryer, and storage building. Estimated cost, \$65,000. C. P. Barnett, architect.

**DECATUR**—The Mueller Metal Co. will build a one-story, 200 x 300 ft. refining plant. J. H. Mueller and Cerro Gordo St. Adolph Mueller, president.

**GRANITE CITY**—The National Enamel-ling & Stamping Co. has awarded the contract for the construction of a one-story, 100 x 100 ft. brick building for steel line burning plant at the Unit Construction Co. Title Guarantee Building, St. Louis Mo. Estimated cost, \$75,000. Noted Aug. 31.

#### Idaho

**MALAD**—The California Sugar Manufacturing Co. will build a factory near E. A. F. Parkette 545 West 28th St., Orem, Utah, preparing plans.

#### Kansas

**BAXTER SPRINGS**—The Ladd Mining Co. will build a 200-ton concentration plant and is in the market for sludge and slime tables, ore bins, jigs, belts, lumber, roofing, engine, hoisters, track, ore cars, conveyors, air compressors, concrete motors, drills and hoisters. Estimated cost, \$60,000. J. L. Ladd, superintendent.

#### Kentucky

**LOUISVILLE**—The Magic Keller Soap Works, 1201 Story Ave., has awarded the

contract for the erection of additions and improvements to its plant to the National Concrete Construction Co., Board of Trade Building. Estimated cost, \$200,000.

**PRESTONBURG**—The Consolidated Oil & Gas By-Products Co. will build an alkali and gasoline plant here. A. B. Brodie, Huntington, general manager.

#### Massachusetts

**CHELSEA**—The Mexican Petroleum Co., Allens Ave., Providence, R. I., has awarded the contract for alterations to its oil plant to Ellis & Haugh Inc., 171 Westminster St., Providence, R. I.

#### Michigan

**DETROIT**—The Detroit Copper & Brass Rollings Mills, Clark Ave., will build an addition to its factory. Smith, Hinchman & Grylls, 710 Washington Arcade, architects.

**DETROIT**—The Michigan Smelting & Refining Co., 1635 Joseph Campau Ave., has awarded the contract for the erection of a factory and cold building to W. E. Wood Co., 1508 Ford Bldg. Estimated cost, \$100,000.

**WYANDOTTE**—The city will build a filtration plant to have a capacity of 12,000,000 gallons. Estimated cost, \$250,000. Winthrop R. Pratt, engineer.

#### Minnesota

**EVELETH**—The city will build two liquid chlorine plants. C. H. Williams, clerk.

#### Missouri

**ST. LOUIS**—The Dielectric Manufacturing Co., 224 South Vandeventer St., will convert two-story flat building into factory for the manufacture of chemicals and insulating material. Dr. J. J. Kessler, president.

**ST. LOUIS**—The Monsanto Chemical Works, 2nd and Lafayette St., will construct a plant for the manufacture of caustic soda and chlorine. John F. Queeny, president.

**MO. ST. LOUIS**—The Ordinance Dept., Wash., D. C., and the Mississippi Valley Iron Co., La Salle Bldg., are negotiating for the establishment of a pig iron plant here to include slake-making plant. Estimated cost, \$10,000,000. E. F. Goltra, president of the Mississippi Valley Iron Co., 6500 South Broadway, in charge.

**ST. LOUIS**—The United Brewing Co., Gravois and Michigan St., will convert its brewing plant into an oleomargarine factory and install new machinery in same. Total estimated cost, \$100,000. Otto F. Stifel, president.

**WACO**—The Cow Creek Mining Co., Carl Junction, will build a 200-ton concentration plant and is in the market for sludge and slime tables, crushers, boilers, motors, roofing, air compressors, pumps, conveyors and drills. Estimated cost, \$60,000. W. H. Clark, superintendent.

**MO. WACO**—The Freehold Oil and Gas Co. will build a 200-ton concentration plant and is in the market for sludge and slime tables, jigs, crushers, belts, engine, hoisters, lumber, roofing, motors, wiring, pipe, concrete and mill hardware. Estimated cost, \$65,000. W. S. Marquiss, superintendent.

#### Nebraska

**ANTIOCH**—The Sheridan Potash Co. has received authorization from the State Railway Commission to sell \$30,000 worth of the stock for the purpose of erecting a ten-ton plant on a lake northeast of Antioch. The lake contains about \$350,000 worth of potash.

**ANTIOCH**—The National Potash Co. will rebuild its plant recently destroyed by fire entailing a loss of \$300,000.

#### New Jersey

**NEWARK**—C. F. Massey, West Bank St., will build a one-story, concrete factory on the Passaic River, for the manufacture of concrete products. Estimated cost, \$15,000.

**PATERSON**—Francisco Santucci, 7 Passaic St., will build a one-story, 50 x 100 ft. brick dry-house at 9-13 Walker St. Estimated cost, \$10,000.

**RAHWAY**—The Philadelphia Quartz Co., Philadelphia, Pa., will build a large concrete and brick factory on a tract of 30 acres along the Central and Pennsylvania Railroads. Estimated cost, \$1,500,000.

#### New York

**ALBANY**—The Patent Vulcanatic Roofing Co., Tivoli St., has awarded the contract for the erection of a 1-story, 70 x 245 ft. factory addition, to the Hamilton Construction Co., Gay Building, Troy. Estimated cost, \$10,000. Noted Aug. 15.

**BROOKLYN**—The State Hospital Commission, Capitol Ave., Hopkiss, will build a sewage disposal system at the Creedmoor Division of the Brooklyn State Hospital. Estimated cost, \$25,000.

**BUFFALO**—The Metal & Alloy Specialty Co., 25 Illinois St., will build a foundry on Marion Ave. for brass, aluminum and other metal castings.

**BUFFALO**—The Prest-O-Lite Co., Speedway, Indianapolis, Ind., will build a charge-discharge plant on Erie St. Building and Tift St. consisting of four 1-story buildings.

**NEW YORK**—Charles Lane, 5 Beekman St., will build a 1-story, 56 x 100 ft. paper factory. Estimated cost, \$15,000. Dietrich Worthman, 114 East 28th St., architect.

**SALISBURY CENTER**—The Board of Supervisors of Herkimer Co. will build a 1- and 2-story brick hospital. Plans include the erection of a bacteriological laboratory. Total estimated cost, \$175,000. R. E. Ghyver, First National Bank Building, Herkimer, architect.

**NEW YORK**—The Rogers-Pvatt Shellac Co., 81 Water St., has awarded the contract for the erection of a one-story, 75 x 36 ft. concrete, brick and steel factory at 32-53 Essex St. to Isaac J. Hopper, 15 East 40th St. Estimated cost, \$25,000.

#### North Carolina

**CHARLOTTE**—Swift & Co., 76 West Monroe St., Chicago, Ill., has awarded the contract for the erection of a 1-story, concrete factory building for the manufacture of salad oil, to J. A. Jones, Realty Bldg. Estimated cost, \$75,000.

#### North Dakota

**GRAND FORKS**—The city will install a chlorine system of water purification. R. E. Murphy, of Wallace, Ternan & Co., superintendent.

#### Ohio

**CINCINNATI**—The American Smelting & Refining Co., 9th and Freeman St., will remodel three of its buildings for manufacturing purposes. Estimated cost, \$20,000. Baumschmidt & Drainie, Gerke Building, architect.

**CINCINNATI**—The Groves Fertilizer Co., Lockland, has awarded the contract for the construction of two additions to its plant: one, 3-story, 60 x 100 ft., mill construction, and other, 1-story, 60 x 200 ft., frame to the M. Marcus Building Co., 2030 Rounding Road. Estimated cost, \$50,000.

**PIQUA**—The city plans to build a water supply system including filtration station at Lorain Creek. Estimated cost, \$330,000. Albert Schroeder, City Building, director of public works, 1200 Whipple Fuller, 30 East 42d St., New York City, N. Y., consulting engineers.

**SANDISKY**—The Musterole Co., 1743 East 27th St., Cleveland, has awarded the contract for the erection of a 2-story, 60 x 70 ft. concrete and brick factory, to George Felek & Sons. Estimated cost, \$25,000.

**WARANA**—The United Paperboard Co., 171 Madison Ave., New York City, N. Y., will rebuild its 1- and 2-story, 70 x 360 ft. factory recently destroyed by fire. R. R. Owens, local manager.

#### Oklahoma

**CENTURY**—The Century Mining Co. will remove its concentration plant from Joplin to Century and remodel same: is in the market for sludge and slime tables, mill hardware, ore bins, ore cars, drills, air compressors, pumps, motors and electric wiring. Estimated cost, \$40,000. J. C. Trout, superintendent.

**DOOTHAT**—The Century Mining Co. will build a 250-ton concentration plant and is in the market for sludge and slime tables, jigs, lumber, roofing, conveyors, crushers, concrete, air compressors, belts, drills, cables, ore cars, ore cars, track incline, hoisters, track cross ties, etc. Estimated cost, \$65,000. Carl Scott, superintendent.



**HOCKERVILLE.**—The Diamond Joe Mining Co., Miami, Okla., will build a 200-ton concentration plant and is in the market for sludge and slime tables, jigs, drills, roofing lumber, engine, boilers, belts, concrete, hoisters, wire cables, air compressors and conveyors. Estimated cost, \$60,000.

**HOCKERVILLE.**—The Miami Volunteer Mining Co., Commerce, will build a 250-ton concentration plant and is in the market for sludge and slime tables, jigs, ore bins, ore cars, ore crushers, air compressors, belts and mill hardware. Estimated cost, \$65,000. Claude Holiman, superintendent.

**LINCOLNVILLE.**—The Canton Mining Co. will build a 200-ton concentration plant and is in the market for sludge and slime tables, ore bins, ore cars, cable, engine motors, belts, lumber, roofing, mill hardware, crushers, pumps, pipe, cement, air compressors, conveyors, drills and jigs. Estimated cost, \$60,000. Otis White, superintendent.

**MIAMI.**—The Right Good Mining Co., Ilathe, Kan., will build a 250-ton concentration plant and is in the market for sludge and slime tables, engine, boilers, pipe, pumps, conveyors, jigs, air compressors, crushers, mill hardware, motors, and slime tables. Estimated cost, \$60,000. C. H. Miller, manager.

**OKMULGEE.**—The city has awarded the contract for the erection of a sewage disposal plant and water-works system, to F. B. McCormick. Estimated cost, \$69,000. Noted July 30.

**PICHER.**—The Amy T. Mining Co. will build a 200-ton concentration plant and is in the market for sludge and slime tables, ore bins, ore cars, crushers, belts, boilers, engine, lumber, pump, motors, air compressors, pipe, pumps and jigs. Estimated cost, \$60,000. Ed. Ballinger, superintendent.

**PICHER.**—The LaSalle Mining Co. will enlarge its concentration plant to have a capacity of 500 tons, use electric motors instead of steam, and is in the market for motors, crushers, jigs, sludge and slime tables, mill hardware, electric wiring, air compressors, roofing, lumber, concrete, drills, belts, hoists, wire cables, scales. Estimated cost, \$100,000. C. L. Funk, superintendent.

**PICHER.**—The Oko Mining Co., Joplin, Mo., will build a 250-ton concentration plant and is in the market for jigs, crushers, rolls, lumber, concrete, roofing, engine, boilers, air compressors, conveyors and mill hardware. Estimated cost, \$65,000. A. Meyerhoff, superintendent.

**POTEAU.**—The American Indian Oil & Gas Co. will build plant to manufacture carbon from natural gas.

**QI'AT.**—C. F. Noble will build an absorption gasoline plant. Estimated cost, \$250,000.

**ST. LOUIS.**—The Prudential Mineral Co. will build a 250-ton concentration plant and is in the market for sludge and slime tables, conveyors, crushers, engine, belts, cable, lumber, roofing, concrete, track cars, cans and jigs. Estimated cost, \$60,000.

**TULSA.**—The Atlas Petroleum Co. will build a third unit to its 2-unit compression gasoline plant here.

## Pennsylvania

**HARMARVILLE.**—The La Belle Iron Works, Oliver Building, Pittsburgh, has awarded the contract for the construction of 12 mining buildings, and 200 brick houses, to the Thompson-Starrett Co., Second National Bank Building, Pittsburgh. Estimated cost, \$1,000,000.

**PHILADELPHIA.**—The Linde Air Products Co., 18th and Cambria Sts., has awarded the contract for the erection of a 1- and 2-story, 35 x 31 ft. manufacturing building, to W. W. Lindsay Co., Harrison Building. Estimated cost, \$63,000.

## Pennsylvania

**WARREN.**—The Union Petroleum Co. will build an oil refinery here. J. C. Kubler, in charge.

## Tennessee

**CHATTANOOGA.**—The Columbian Iron Works will rebuild its plant for the manufacture of shells recently destroyed by fire entailing a loss of \$100,000.

## Utah

**SALT LAKE CITY.**—The Burdett Oxygen Co., 363 Eccles St., will build an addition to its local plant to handle war contracts.

## Virginia

**CAMP STUART.**—The Construction Division War Department, Washington, D. C., will build laboratories, storehouses, nurses' infirmary, etc., at the base hospital here. Estimated cost, \$448,200.

**GRAHAM.**—The Pocahontas Manganese Corporation will build additions to its plant. The company recently increased its capital from \$25,000 to \$100,000.

**YORKTOWN.**—The Bureau of Yards & Docks, Navy Department, Washington, D. C., has awarded the contract for the erection of a fuel oil plant, with equipment, to the F. W. Mark Construction Co., Finance Building, Philadelphia, Pa. Estimated cost, \$500,000.

## West Virginia

**FAIRMONT.**—The Construction Division, War Department, has awarded the contract for the erection of a phosphorus plant near here, to the American Phosphorus Co., 3rd and Dauphin St., Philadelphia, Pa. Estimated cost, \$500,000.

**HUNTINGTON.**—The Northern Alkali & Chemical Co. will build a caustic potash factory to have an output of 1000 lb. daily, and is in the market for tanks, kettles and filter press.

**SPENCER.**—The International Gasoline & Oil Co., Fulton Building, Pittsburgh, Pa., will build a 1-story, 30 x 50 ft. gasoline refinery. Plans include the erection of a concrete engine house, compressor house, pump house, etc.

**SUTTON.**—The Sutton Chemical Co. will build a 1-story, 33 x 157 ft. chemical plant and a 1-story, 48 x 145 ft. retort house. Wm. McCabe, manager.

**WELLSBURG.**—The Eagle Glass & Manufacturing Co. has awarded the contract for the erection of an addition to its plant, to E. A. Crasman.

**WHEELING.**—The City Council will install a filtration plant, Chester & Fleming, Union Bank Building, Pittsburgh, Pa., engineer.

## Wisconsin

**BERON.**—The Consolidated Water Power & Paper Co., Grand Rapids, will build a 2-story addition to its paper mill here. L. A. DeGuere, Grand Rapids, architect.

**WAUWATOSA.**—The North Western Chemical Co., 61st and State St., will build a chemical plant. C. F. Ringer & Sons, University Building, Milwaukee, architect.

## Wyoming

**SUPERIOR.**—The Liberty Potash Co., will build a plant to extract potash from leucite rock, near here. C. R. Eastcourt, \$100,000. Guy Sterling, Newhouse Building, Salt Lake City, Utah, engineer.

## Canada

### British Columbia

**TRAIL.**—The Consolidated Mining and Smelting Co. will rebuild its roaster plant recently destroyed by fire entailing a loss of \$50,000.

### Nova Scotia

**WHYCOCONAGH.**—The American Syndicate has awarded the contract for the erection of a fire brick plant, to Wells & Gray, 701 Confederation Building, Toronto, Ont. Estimated cost, \$150,000.

## Ontario

**BRAMPTON.**—The city has awarded the contract for the erection of a sewage disposal plant, to G. C. R. Eastcourt, 250 Adelaide Ave., Toronto. Estimated cost, \$11,055. Noted Aug. 31.

**IAWKESEBURY.**—The Town Council has awarded the contract for the erection of a filtration plant, to Archambault & Leclair, 616 St. Denis St., Montreal, Que. Estimated cost, \$48,000.

**KIRKLAND LAKE.**—The Burnside Gold Mines, Ltd., is in the market for a ball mill, having a capacity of about 40 or 50 tons, electrical equipment, etc. C. A. Richardson, manager.

**LEASIDE.**—The Leaside Munitions, Ltd., will build a 2-story, 60 x 65 ft. plant here. Estimated cost, \$50,000.

**NEW TORONTO.**—The Village Council has awarded the contract for an extension to its filter house, to R. C. Hoffman.

**TORONTO.**—C. Goodman & Co., 76 Starford St., is in the market for a carbonizing machine capable of carbonizing anything from 100-300 pound batches.

**TORONTO.**—W. Harris & Co., Danforth Ave., has awarded the contract for the erection of a glue plant, to Archibald & Holmes, 36 Toronto St. Noted Aug. 15.

**TORONTO.**—Sanderson & Percy, 88 Adelaide St., West, will build a 1-story, addition to its factory, for the manufacture of paints and oil. Estimated cost, \$15,000.

## Saskatchewan

**ROSTERN.**—The Town Council will build a sewage disposal plant. Estimated cost, \$15,000. R. S. Pleury, mayor.

**SASKATOON.**—The Research Council will build a plant to experiment in producing gas from waste straw. Estimated cost \$15,000.

## Industrial Notes

**THE GOODYEAR TIRE & RUBBER COMPANY,** Akron, Ohio, have military training classes which have been in progress ever since our country's entry into the war. They have now been extended to include all inspectors and foremen, adding 1300 men to the ranks that had been taking advantage of the opportunity to acquire a comprehensive acquaintance with military tactics and practice.

This new feature is designed as a part of the regular duties of all inspectors and foremen during their regular working hours on Wednesdays and Fridays of each week, and applies to all alike, even to those holding military rank, except those being certified by the company's physicians.

Drills are held at Selberfield Field, the big athletic grounds of the company, under the supervision of the regular drillmaster and his corps of assistants. As the factory operates in three shifts of eight hours each, the drills are also conducted in shifts. Military drill has been popular at this plant, as is amply evidenced by the large numbers of employees that have voluntarily entered the various drill classes. These classes, however, have not been limited to classes for men, for a large number of girls have been drilling regularly ever since the army was first presented, and have become proficient in their military exercises.

The Goodyear Company now has an army of its own numbering 2000 some of whom will ultimately be called into their country's service, and when that time comes will be much better equipped than the raw material entering our training camps, without any previous training or military experience.

Many former employees who have received rapid promotions from the ranks as non-commissioned officers or have been highly recommended for commissions in the various officers' training camps, have written that in large part they owed their success to the previous experience they had received in the Goodyear drill classes. Some of these boys, who have received commissions in the army, have since had the pleasure of drilling the Goodyear classes, while home on furloughs.

It is the belief of the Goodyear officials that military training teaches accuracy, promptness, efficiency and discipline, and gives an all-around training to the body. An in the hope that these benefits might be shared in by its workmen, have placed at the doors of its workers opportunities to acquire them.

## Manufacturers' Catalogs

**THE CUTLER-HAMMER MFG. CO.,** Milwaukee, Wis., call attention to Publication 271 entitled "War-Time Control of Lights," Booklet F, August, 1918, on "C-H Iron-Clad Solenoids," which are particularly adapted for operating brakes used in connection with crane, elevator and hoist motors and Booklet G, August, 1918, on "Magnet-Operated Brakes for Direct Current Service."

**THE WALTER A. ZELNICKER SUPPLY CO.,** St. Louis, Mo., Bulletin No. 246, dated July 25, 1918, dealing with tanks they have in stock. Bulletin No. 247, August, 1918, on equipment and machine tools, for locomotives, cars, trucks, shovels, ditchers, loaders and loaders.

**THE WHEELER CONDENSER & ENGINEERING CO.,** Carteret, New Jersey: Bulletin 112-A on condensers, pumps, cooling towers, etc. There is a discussion in this bulletin entitled "Choice of Condensate," and also the remainder illustrates and describes other condensing machinery in detail.

# CHEMICAL & METALLURGICAL ENGINEERING

A consolidation of ELECTROCHEMICAL & METALLURGICAL INDUSTRY and IRON & STEEL MAGAZINE

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## Steel Conditions

### After the War

RECENT diplomatic and military developments have not indicated when the war will end, but they have suggested quite clearly that when the war does end it will end much more suddenly than was previously assumed. As to conditions that will exist in the steel industry after the war, accordingly, there is marked out a special period of transition from war time conditions to the conditions that will exist for a period of years after the war. There has been much discussion as to the demand for steel that will exist for several years after the war, for reconstruction and other purposes, but it is now clear that there is to be an intermediate period of transition. Some of the foreign belligerents have adopted more or less explicit reconstruction programs, which may or may not function well at the outset, while the United States has adopted nothing, and has not even settled upon a basis on which a program can be constructed.

It is regarded as an item of progress that the authorities at Washington have let it become known, unofficially, that they purpose to retain, after a declaration of peace, some measure of the control they have exercised over industry during the war. We have become so accustomed to the issuance of orders and requests, and compliance therewith, that it is somewhat difficult to realize how different basic conditions will be when peace comes. The War Industries Board is constituted to exist for six months after peace is declared, but the continuance of its authority is another matter. For illustration, the board's regulation of steel prices is the result of an agreement between it and the producers of steel. If the steel producers had refused to agree to the fixing of maximum prices, the President had the authority of the act of June 3, 1916, "in time of war or when war is imminent" to fix fair prices at which the Government would buy, and there was also the prospect, in case an agreement could not be reached, of Congress acting, as it did in the Lever act in the case of "food, feed and fuel." None of this applies to the period after the war, while furthermore effective regulation would cover not merely maximum prices, as hitherto, but minimum prices also, for it is distinctly stated that the regulation contemplated is intended in part at least as a protective measure to manufacturers. An agreement among producers would be necessary, and interesting questions naturally arise as to the legality of such operations.

Apart from the very difficult subject of Government regulation there is the fact that a large part of the steel demand that has been banking up is demand for steel for construction purposes. The investor must have an

idea of the conditions likely to exist during the period of years in which the investment is to yield revenue and return the principal. He cannot be expected to act hastily. His buying of steel is not likely to be a factor in the transitional period. When the investor begins to buy, that will be a signal that the transitional period is over and that business has settled down to the work of the period of years in which the world will rehabilitate itself.

As to international trade in iron and steel no subject could well be more confused. There are wide divergences between the set prices for steel products in the United States and Great Britain, and there are wide divergences in the profits vouchsafed to manufacturers by these prices. That there will be great readjustments in costs goes without saying, but where they will tend to land the industries in the various countries, as to international competitive conditions, is a conundrum. If it is to be a case of *laissez faire* a period of years will be required for the adjustment.

The importance of the changes in international competitive conditions in iron and steel that will result from the rearrangement of the Minette ore field appears to have been magnified by many who have undertaken to discuss that subject. It has been formally announced at Washington that return to France of the portions of Alsace-Lorraine taken by the Germans in the settlement of the Franco-Prussian war is part of the American program, as it has been right along of the French program. Some observers in the past have ventured to assert, as an argument on this subject, that the Germans need the ore and the French cannot use the extra quantity, but it is not necessarily a part of the peace program that international trade in this ore be prohibited. It flourished before this war, in the form of a complicated interchange of self-fluxing and siliceous ores, and it can be established on new lines, calculated indeed to furnish an additional safeguard that Germany shall not make iron and steel for military purposes. Important as the Minette ores are, the entire region has furnished the basis for much less iron production by France, Belgium, Luxemburg and Germany than the production in the United States. The mere difference between the greatest production of pig iron in the United States before the war and the present rate of production is more than one-half the production of all countries credited to the use of Minette ore.

#### Help For the Gold Producer

TO POINT out the distressing situation of gold producers is becoming almost hackneyed. Apparently their metal is much in demand, yet its selling price may not be increased despite the small production. Thus gold is one commodity which falls without the scope of that trusty sheet-anchor, the Law of Supply and Demand. The profits of most of these producers steadily approach zero between the factors of diminishing ore tenure and increasing costs for labor, supplies and overhead. The situation is not local—from West Australia, South Africa and Canada comes the same plaint.

A well attended conference of Western producers, called by the Governor of Nevada, met at Reno in August. This meeting was a unit in asking for immediate relief and in condemning a change in price, but

unfortunately it was able to suggest no path out of this evident *cul-de-sac*. This is distinctly unfortunate. If they, who are vitally interested in the ways and means of gold production and acquainted with its importance to industry and finance, can suggest no sound workable method of relief, it is idle to expect politicians or others to study out the riddle. Thus it was that only the energetic propaganda of Western bankers succeeded in overcoming the general ignorance, suspicion and apathy of the recent meeting of the American Bankers' Association to a sufficient degree to have them refer the matter of gold supply to a standing committee for further investigation.

The Spokane Conference of Canadian and American producers held in September attempted to take this needed step in advance of its forerunner at Reno. After asking for a governmental investigation of the situation, it proposed several avenues of relief, any or all of which would be of material assistance. The exemption from assessment work, building of motor-truck roads, and extension of governmental credit would aid in the development of new producers and could readily be handled by a Minerals Administration. Priority of supplies, machinery and transportation and the allocation of labor can now be extended by existing governmental agencies in all countries, and in a very large number of cases would relieve the situation enormously. Under the circumstances it appears that an insistence upon these steps would be the best course of endeavor, since special class legislation toward pre-war freights and taxes would erect instant and powerful opposition.

It is unfortunate that after voting against a change in the present price, the conference fell into the inconsistency of proposing a bounty. One can hardly appreciate the specious arguments which led them to the delusion that a bounty is not tantamount to an increased price. Else in what currency are they to be paid? One flippantly might suggest that the bounty might be paid in zinc, thus coming to the aid of the zinc market at the same time gold is protected! Evidently it cannot be paid in gold, nor is it permissible to sell the metal on a free market. What a chance for a Get-Rich-Quick Wallingford if he could sell gold to jewelers for \$25 an ounce and get his pay in gold notes!

Why cannot we recognize the fundamental reason before it is too late and disaster ensues? Commodity prices are too high for safety not only to gold production, but to the whole industrial fabric of our nation. They must come down before they pull the entire superstructure upon our heads.

#### Inscrutable in the Ultimate

THE Administrative Chairman of the Honorary Advisory Council for Scientific and Industrial Research of Canada is publishing in installments a report of the Council's activities. The initial number is before us and we are informed that it is from the pen of Professor A. B. Macallum, the administrative chairman, and that it reflects more particularly his own views than those of his associates. In other words, that he is solely responsible for the opinions expressed. A large number of questionnaires have been sent to manufacturers and others and the returns, we learn, are in process of tabulation.



The value of such a body may be almost infinitely great, provided it undertakes its work with vigor, intelligence and understanding. On the other hand, unless it is exceedingly practical in coupling its efforts with measures relating to the general welfare, it is likely to lose public support, which is always a misfortune. Unnecessary duplication is another subject to be avoided, for research is research no matter where it is accomplished. One of the gravest errors made by the Germans was to cherish the belief that only they could practice applied chemistry. It was an expensive error.

Professor Macallum calls urgently and wisely for a great Institute of Research, and along with it he demands a Canadian Bureau of Standards. Now there is an excellent Bureau of Standards in Washington, the British standards are well organized and controlled in England and the two work together in harmony, but we have no desire to discourage the establishment of another bureau in the Dominion. If, however, they were to institute the metric system and were to co-operate with the French Bureau, some of us would wish them God-speed while others, both in the United States and Canada, might become addicted to tooth-nashing, for to some minds the metric system is like a red rag to a bull. But there is no intimation of co-operation with France in the report.

Elsewhere Dr. Macallum expresses an opinion that seems to us to be pointed straight in the wrong direction. He says of Canadian industrial establishments that many of them are not in a position to undertake research on a large enough scale to insure results, which is perfectly true, in Canada and everywhere else. He says also that they can enroll themselves in American associations formed for the purpose of solving their problems by research and that some of them have already done so. Also true. He even says that such co-operation *may* be unobjectionable and that there are no international boundaries in science.

It is what follows that pains us. "There are reasons," says he, "why this co-operation cannot be erected into an international system. Some of these concern a cast of psychology inscrutable in the ultimate, if you will, but nevertheless potent in directing a policy on this question. Our people could not ultimately be brought to approve of any proposal, however luring it might appear to them, if also its acceptance involved an effacement of the pride and independence that nationality essentially predicates."

That sentiment appeals to us as rank poison. German propagandists have long been sowing the seed of just such ideas. If honest men of Canada and the United States engage in research for the general welfare, we are simple-minded enough to believe that they can be trusted to proceed without "ultimate" designs upon the well-being or estate or patriotism of their associates. The chicanery he refers to is the kind of chicanery we are fighting to stop. It is intelligent rather than slick or smart or sharp to engage in industrial research. The only safe way to play the industrial game is with the cards on the table. In the "ultimate" many citizens of the United States may move to Canada and *vice versa* for industrial purposes, and even that is no great tragedy. Both countries can stand it; both have resources enough and to spare without setting up a cry over it. We live side by side, we are neighbors, we

are in the same fight for the same good cause and we cannot see the hazard that apparently is the basis of Dr. Macallum's suspicion. We sincerely hope that Canadian organizations for research and study will continue to welcome Americans as members and that our neighbors in applied science will continue to affiliate with such establishments on this side of the border. Let us put no barriers in the way of industrial research. We regret that Dr. Macallum has taken the attitude displayed in his official report.

### The Development of Water Softening

IN THE eventful years around 1770, when BURKE was pleading the cause of the colonies before the English parliament and predicting the wonderful future growth of these vast territories on the far shores of the Atlantic, WATT, the inventor of the steam engine, initiated the means for bringing BURKE's forecasts true, and LAVOISIER, the chemist, likewise gave the science of materials an impetus essential to the progress of the subsequent developments in engineering.

One of the most interesting features of the philosophy of the ancients was the theory that earth was formed from water. It was thus that they accounted for the islands and land apart from the seas, and there could be no dispute about it, because earth residues always accompanied the distillation of water. LAVOISIER, in his paper before the Académie des Sciences<sup>1</sup> in 1770, "On the Nature of Water and on the Experiments Adduced in Proof of the Possibility of Its Change into Earth," not only put an end to the water part of the time honored Fire-Water-Air theories of matter, but put the quantitative chemical science as instituted by JOSEPH BLACK and HENRY CAVENDISH on a firm basis in Paris, the capital of science at that time. Professor BLACK's researches on "fixed air" (CO<sub>2</sub>), burnt lime and the production of caustic potash form the premier study on quantitative chemical work. In subsequent years when boiler scale became important enough to command the attention of scientists, it was Professor CLARK of Aberdeen who profited from the work of BLACK and LAVOISIER and patented (1840) the softening of carbonated hard waters by neutralization with burnt lime. He thus started the cure of the trouble by the removal of the cause. In the eighty years of the Clark process, many improvements in both machinery and process have been made, which are so well known that they need not be described here.

Among the articles in this issue, considerable space has been allotted to the "Chemical Control of Water Softeners." The importance of water treatment is so fundamental to the needs of mankind that it has almost established a separate branch of engineering, located somewhere between chemical, civil and mechanical engineering. Recognizing that water treatment operations are not always under the control of men highly trained in stoichiometry and that softening machinery is often not installed, where needed, because it is considered too difficult to operate in small isolated operations, we are offering Mr. CLARK's paper in the hope that it will answer the requirements better than any of the prior literature on the subject.

<sup>1</sup>Enones, 11 (p. 1).

## Readers' Views and Comments

### Consumption and Conservation of Tin

*To the Editor of Chemical & Metallurgical Engineering*

SIR:—The Bureau has noted your anonymous article under the above title on page 175 of the August 15 issue of CHEMICAL & METALLURGICAL ENGINEERING. Since the main part of this article follows an extract from a report of the War Industries Board, and from the wording of that extract it might appear that the comment on tin-base bearing metals and solders originated from the Bureau of Standards, we wish you would call your readers' attention to the fact that such is not the case. There are statements in the article to which we cannot agree and which might defeat the Bureau's efforts on tin conservation.

The Bureau of Standards has developed solder composed of 80 per cent lead, 10 per cent tin and 10 per cent cadmium which is being used as a successful substitute for ordinary solders. It has been tried in many industrial applications and has been found very satisfactory.

S. W. STRATTON.

Bureau of Standards,  
Washington, D. C.

\* \* \*

The purpose of the article referred to was to indorse the movement for the conservation of tin and it would be unfortunate if it should in any way defeat the Bureau's efforts in that direction. Our statement to the effect that "metals such as cadmium have been tried as substitutes but are not of practical economic use" was based on the fact that cadmium costs per volume over three times as much as tin, oxidizes slightly above its melting point and does not give as strong a joint as regular solder. We are gratified to learn, however, that the Bureau of Standards has developed a satisfactory solder which should find wide use in view of the necessity of conserving tin. It should be needless to add that it is and has been at all times our desire to co-operate with the Bureau in its excellent work.

In a communication received subsequent to that published above, the Director of the Bureau states that while the relative cost of cadmium is greater than that of tin, only 10 per cent of cadmium is used in the substitute solder so that the entire metal cost of the cadmium-tin-lead solder is less than 35 cents per pound.—EDITOR.

### The Cotton Oil Industry in the War

*To the Editor of Chemical & Metallurgical Engineering*

SIR:—In reading your very interesting account of the Cleveland meeting I noticed on page 548, Vol. 19, No. 7, a mis-statement in regard to the amount of oil which must be cleaned out of a ton of cotton seed. What I said was that it used to be considered good practice to get from 35 to 40 lb. of linters per ton of seed but the mills are now expected to obtain 145 lb. The price fixed on cotton seed varies by zones, according to the average amount of oil contained in the seed for each zone.

DAVID WESSON.

New York City.

### Effect of Oxygen on the Precipitation of Metals from Cyanide Solutions

*To the Editor of Chemical & Metallurgical Engineering*

SIR:—The abstract on page 283 of your issue of Sept. 15th of the important paper by Mr. T. B. Crowe on the above subject has been read with much interest. While admiring Mr. Crowe's ingenuity in bringing about so great a saving in the cost of cyaniding by the simple expedient of removing the dissolved air before precipitation by zinc, the writer cannot agree with Mr. Crowe's views in regard to the mechanism of the process.

In opposition to his view that precipitation of gold is brought about by hydrogen which has been displaced by zinc, and that the removal of dissolved air is beneficial because it prevents oxidation and loss of this reducing agent, the writer considers that the gold is directly displaced from solution by zinc, just as the same metal displaces copper from a solution of copper sulphate. The dissolving of zinc in a solution of pure sodium cyanide is a case of the displacement of one element by another, and differs from the dissolving of zinc in copper sulphate only in that hydrogen is displaced instead of copper.

It is this difference in the material displaced from solution that makes oxygen a necessity for the rapid dissolving of zinc or other metals by cyanide solutions, while the presence or absence of oxygen has no marked effect on the rate of dissolving of zinc in a solution of copper sulphate. If a strip of zinc be placed in an excess of dilute sulphuric acid the metal begins to go into solution and hydrogen is displaced; because the potential of zinc, or its tendency to dissolve, is greater than the discharge potential of hydrogen on the same metal, i.e., the force required to precipitate hydrogen, this action continues until all zinc has disappeared. If, however, the zinc be amalgamated, it is no longer appreciably attacked by the acid, although after amalgamation the zinc shows practically the same potential as before; it is because the discharge potential of hydrogen on mercury is greater than the potential of zinc in sulphuric acid that there is no visible evolution of hydrogen on amalgamated zinc. The displacement of hydrogen undoubtedly begins, but the potential of the cathode in the voltaic cell constituted by the mercury and zinc is raised by the layer of accumulating hydrogen until it equals the potential of zinc. When this occurs, dissolving of the zinc must cease. If now an oxidizing agent be added to the acid, or air be blown in, the zinc will dissolve, for removal of the film of hydrogen by oxidation enables the zinc to displace a new quantity of hydrogen. In this way the dissolving of zinc will continue so long as the hydrogen which it displaces is continually removed.

In a solution of sodium cyanide ordinary zinc acts like amalgamated zinc in acids, i.e., the hydrogen which the zinc displaces when it dissolves must be removed from the surface of the metal in order that continuous solution of the zinc may occur. When zinc is immersed in a dilute cyanide solution containing gold,

two reactions occur side by side; first, some of the zinc is dissolved by the double cyanide of gold with precipitation of gold; second, a portion of the zinc dissolves in the sodium cyanide with the displacement of hydrogen. Only the first action is useful. Every gram of hydrogen that appears means that 32.5 grams of zinc has dissolved without precipitating any gold, and that the amount of cyanide with which this zinc has combined is also wasted. Fortunately this wasteful dissolving of zinc is strictly limited to the amount of oxygen or air available for oxidizing the polarizing film of hydrogen.

Besides causing a loss of zinc in the manner indicated, dissolved air lessens the efficiency of recovery by accelerating re-solution of the gold already precipitated, just as air aids the dissolving of metals in cyaniding ores. It is this two-fold action that makes dissolved air a factor to be reckoned with in the economics of gold recovery.

OLIVER P. WATTS.

Chemical Engineering Dept.,  
University of Wisconsin.

## Special Gold-Recovery Processes Practised by the Early Portuguese and Spaniards

To the Editor of Chemical & Metallurgical Engineering

SIR:—When I had the pleasure of reading your number of METALLURGICAL & CHEMICAL ENGINEERING of June 1, 1918, I came across a very interesting letter, page 565, entitled "Special Gold-Recovery Processes Practised by the Early Portuguese and Spaniards," and I was the more interested in it as I have a personal experience of over nine years in gold mining in the State of Minas (Brazil), and I can therefore assure you that the facts related by Mr. Kirby Thomas are quite correct, and that this process is still being used now-a-days not only by the natives, but also by the most up-to-date gold mines in that country.

There is not the slightest doubt that it saves a fair amount of gold which would be lost by flotation.

It was specially used by the mining companies I was working with to facilitate the final obtention of the free gold in the *batea*. This primitive instrument (of African origin, if I am not mistaken and therefore probably invented by the early Egyptians) is nevertheless very efficient, and it is regrettable that its use is not more general outside of Brazil.

The plants yielding the sap which is employed to precipitate the floating gold are very numerous, but nearly all belong to the *solanea*, and the juices of this species are always slightly alkaline. Practically, however, only the sap of the plant called *jurubeba* is used by the natives—this mainly on account of its large leaves, which facilitate the obtention of a fair amount of sap without having too much trouble in gathering the primitive material needed. These leaves are roughly crushed by hand in a mortar and the whole pulp together with a small amount of water is put in a cloth and wrung to press out the liquid, which can then be used directly to precipitate any floating gold.

To do this, part of the water on top of the very rich sand contained in the bottom of the *batea* is drained off till the concentrates are uncovered. Some small particles of gold being thus allowed to dry would naturally float if more pure water was added to continue concentration. To obviate this the operator scoops up in his hand an amount of the *jurubeba* juice kept in a

special vessel, and sprinkles it very vigorously over the concentrates contained in the *batea*; and then adding the necessary amount of *jurubeba* juice, finishes the cleaning of the gold by skillful action of the *batea* without losing any gold by flotation on account of the vegetable liquid used.

I may add that the chemist in charge of the reduction department of that mine devised a strake concentrator in which the sap of the *jurubeba* was used instead of water to further concentrate the sands from the stamp strake, the solution being kept in circulation by a small centrifugal pump, it being naturally filtered after leaving the canvas-covered strakes and before being sucked up again by the centrifugal pump.

Personally I cannot give a very definite explanation of the action of the *jurubeba* juices, but I believe the action is just a cleansing process.

For instance, in the case of the floating needle which will not float if it has been cleansed or washed thoroughly with soap or sand-papered so that no particle of grease remains, it is sufficient to pass the needle through the fingers, or better still through the hair to restore its floating properties, showing very clearly that it is only necessary to have an infinitesimal film of greasy matter which naturally does not allow the water to wet the needle, and thus forms the depression on the surface of the water which supports the needle. And further I may note again that if you use instead of water a very slightly alkaline solution, the needle will not float, this being sufficient to neutralize the grease.

Now for this reason I think that the action of the *jurubeba* juice is very similar to this, because you must remember that the stamping process, as well as the friction in the *batea*, tends to polish the gold flakes, and they are therefore with difficulty wet by common water, but easily by the *jurubeba* juice, it being as aforesaid slightly alkaline.

Moreover the Portuguese when treating refractory ores used to slime the concentrate by grinding it under two flat stones, which form a small arastra, a process they used to call burnishing, showing you well that the small flakes of gold enclosed were polished.

Resuming I may say that this action of the vegetable sap of the Brazilian plants has quite a contrary effect to the one in the flotation process, as instead of trying to make the mineral particles float they try to make them sink, but the phenomena are explanatory of each other, as in the flotation process you try either to grease the mineral particles by the use of a small proportion of oil or create a gaseous film around these particles by acids which react on the concentrates, this gaseous film not allowing the mineral particles to be wet, just as the oil did it in the previous case, although in the latter case the gaseous film clinging to the mineral particles reduces at the same time their specific gravity.

In closing it may be interesting to note as an illustration of the skill acquired in working the *batea* that I tried an experiment with one of the women who was particularly clever in its use at the mine. To ten pounds of straight sand (the amount held in the *batea* ordinarily) I added 0.10 grams of fine assay gold which the woman then washed by the above method, and at the last she returned to me from the precipitate at the bottom of the *batea* 0.09 grams.

E. JORDAN.

240 Quebec Ave.,  
West Toronto, Canada.





ever, the impression is abroad that molybdenum alloys are more brittle than the corresponding tungsten equivalents, and are very tender under heat treatment. Thus the ordinary class of labor and equipment in the hardening room will give non-uniform results, which of course is fatal to its use in high-speed tools or modern ordnance.

## Built-in Laboratory Retort

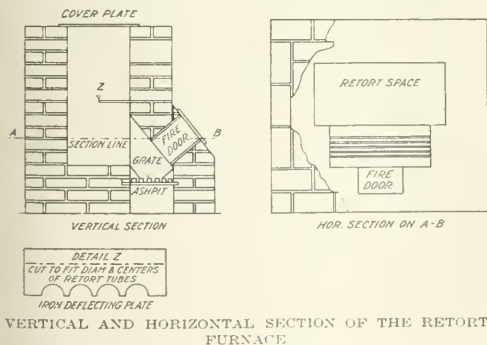
By F. E. COOMBS

THE field of research in dry distillation is daily widening and increasing in importance. So far, there has been nothing offered in the way of experimental apparatus, either for operation on a small laboratory scale, or for commercial testing with large quantities. This article is descriptive of a still which has been in actual service found very easy to handle and entirely practicable, allowing the collection of gases as well as condensibles, and the isolation of all of the carbonized residues for exact weighing. It is especially valuable for finely divided materials, and for all high-temperature sublimations of non-corrosives.

In the accompanying drawings dimensions are not shown, as the scale will be sufficient guide. It is also to be noted that the header and cover-plate of the retort proper will be made of a suitable width to give a flange of about three inches, inclusive of the recess for the metallic seal, and that a clearance of about one-quarter inch should be allowed for around the tube openings, to give easy handling of the sheet metal containers.

The apparatus as scaled in the assembly sketch of the retort carried, in its four tubes, about fifteen pounds total of rather light powdered material, and the 4-in. diameter permitted complete carbonization in about thirty-five minutes.

The essential parts comprise two castings, of which



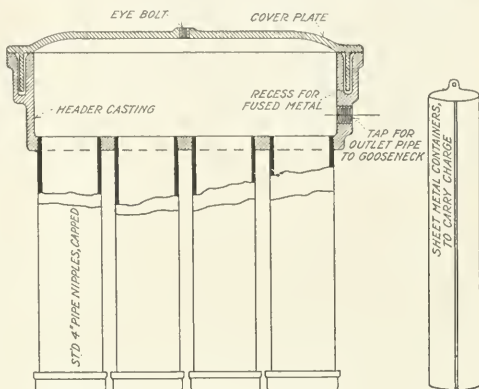
VERTICAL AND HORIZONTAL SECTION OF THE RETORT FURNACE

one is a chambered header with four threaded holes for the capped pipe nipples, and at its upper end a flange and a deep, narrow recess, to be filled with lead, or any alloy of convenient melting point, and further provided with a boss tapped for the outlet pipe, which pipe should be not less than 1½ in. in size. Upon the flange of the header casting rests a cover member, tapped for a strong ring bolt and having a continuous web, vertical to the flange, which fits very loosely into the recess of the header, and should seal therein in the fused alloy to a depth of about 2½ in. at the least.

Eight sheet-iron carrier cylinders are made which

fit easily into the capped pipes, without binding, and a perforated ear on each gives means for attaching an iron hook. With these containers the finished charge can be taken out and the newly filled set inserted in less than two minutes from opening the furnace to closing it again with a fresh charge.

The bottoms of the containers can be permanently closed; but in apprehension of trouble in cleaning out char, the sets actually made were merely flanged over inwardly at the bottoms, and loose round caps of sheet



CROSS-SECTION OF RETORT SHOWING HEAD, COVER AND CONTAINERS

metal used for closing. This was absolutely satisfactory, and no leakage occurred in filling or retorting.

The retort should be set in a brick furnace of proper form, which may be like the one shown and used, but in any case must have a deflecting wall, or plate, for securing a back-and-forth passage of the gases, so that the top will be heated as well as the bottom.

Over the top of the furnace is a pulley and rope, with an iron hook to fit the ring in the furnace top plate and the one in the retort cover-plate. The same rod may be used for removing the containers, but it will be found better to use a separate hook-rod for these, so that they may be swung freely to the closed can be used for preventing the combustion of the red hot coke of the discharge.

The exit pipe, or gooseneck, will project through one end of the furnace wall for connection to condenser.

The empty retort and cover are heated first, and the lead permitted to melt in the recess. When hot enough not to "freeze," the prepared containers are rapidly dropped into place, and the cover plate and furnace cover laid on. Distillation starts almost at once, but not too rapidly, as the capped pipe nipples will have just lost redness by the time the new charge is set in and the cover is on. Header free space is large enough to give a dust chamber, and sudden expansions or excessive gas evolutions may lift the cover but will not damage the apparatus. All or any less number of the carriers may be inserted, according to the freedom of evolution, and the retort is free of the furnace wall.

While the right to patent protection is reserved on large commercial forms of this design, the use of a four-chambered apparatus of 100 lb. capacity, or under, is open to public use.

Floriston, Cal.

## Symposium on the Conservation of Tin

A Discussion of the Tin Alloys—Bearing Metals, Solders, Bronzes and Substitutes—Conservative Spirit Displayed—Considerable Data Being Compiled by the Bureau of Standards on the Use of Cadmium Substitutes

AT THE Milwaukee meeting of the Institute of Metals Division of the American Institute of Mining Engineers held Wednesday morning, Oct. 9, several most prominent metallurgists read papers connected with our present tin situation. MR. GEORGE C. STONE called the meeting to order. MR. W. W. COWAN read DR. G. W. THOMPSON's paper in which he endorsed the increased use of lead in solder and bearing metal alloys.

### THE COPPER-BASE BEARING METALS

MR. G. H. CLAMER gave an excellent review of the use of lead in copper-base bearing metals as follows: In the early days, copper-tin alloys were almost universally used, the idea then being prevalent, and is still held by many, that a bearing to resist wear must be hard, and the harder the better. The favorite bronze bearing contained 90 per cent copper and ten per cent tin; frequently, in service which was considered severe, even higher proportions of tin were used. Such hard alloys have great resistance to compression, but as a rule they had a very wide factor of safety in this respect. Such bearings, because of their inability to adjust their surfaces to slight irregularities in the journal, or to foreign bodies, immediately begin to cut, and heating results. With a slight rise in temperature, the film of lubricant becomes thinner, and further cutting follows, if not actual gripment of the bearing with the journal.

Many years ago Dick, of England, appreciating the advantage to be derived from a slight plasticity in a bearing, added some lead to the then standard bearing metal, not substituting lead for tin but reducing the copper, and produced the alloy, which has long held favor as a bearing metal, copper 80, tin 10, lead 10 per cent. Dick's alloy also contained some phosphorus, but the main point is that this was the first step toward the production of bronze alloys having a plastic nature. Lead does not unite to form an alloy with copper, but remains mechanically mixed, so that structure of the alloy is that of a hard matrix with the soft metal imbedded therein.

It was not until several years later that tests were conducted on the Pennsylvania Railroad, under the direction of Dr. C. B. Dudley, who investigated the copper-tin-lead series within certain limits of the 80-10-10 alloy; he studied, not only the alloys containing lead above 10 per cent in which copper was replaced by lead, but also in which tin was replaced by lead. His conclusions, which have since become firmly established, are: (1) The rate of wear diminishes with increase of lead in the alloy. (2) The rate of wear diminishes with decrease of tin in the alloy. Fortunately, the alloy containing least tin and highest lead exhibits least tendency in service to give trouble from heating.

Notwithstanding the decided merit of copper-tin

bearings containing lead, prejudice was strongly against them, simply because lead is a low-priced metal. It was even intimated that such alloys were frauds, should be considered such, and dealt with accordingly.

I have mentioned Dr. Dudley's discoveries because it was due to its findings that the Ajax Metal Co. instigated research work, now 20 years ago, which has led to the production of alloys still higher in lead and lower in tin than those which he was able to produce. He experienced foundry difficulties which apparently limited his maximum lead alloy to 77 copper, 8 tin, and 15 lead. This was called Experiment B alloy, and has since been widely known as "Ex. B metal."

Having found due regard to the raw materials used, and by following good foundry practice, we have been able to produce alloys carrying 5 per cent of tin and as much as 30 per cent of lead which would show no segregation of lead, even if cast into large bearings. By this I mean that such bearings will show no indication of metallic lead upon any surfaces. Lead being only mechanically held in the alloy, it is prevented from segregating by the quick setting of the matrix of copper and tin. As a certain interval must necessarily occur between the time when the metal enters the mold and the time when it solidifies, the lead always shows some tendency, owing to its high specific gravity, to liquefy toward the bottom of the casting. In bearings made of the proper raw materials, and correctly handled, the difference in the proportion of lead is not usually over a fraction of one per cent, or at most 2 or 3 per cent, the top and the bottom of a casting, even if this be a fairly large one, and made of the 30 per cent lead alloy.

I do not wish to repeat here data which I have given in previous papers<sup>1</sup> but I do wish to set forth the position which the high-lead and low-tin alloys developed by us have attained. When these alloys were first produced they were backed only by laboratory tests and by the predictions of Dr. Dudley that, if such alloys could be commercially produced, the law which he established would no doubt apply also to alloys higher in lead and lower in tin than those which he had developed. It is now possible for me to review 18 years' experience with the manufacture and service of such bearings. I must confess that in our enthusiasm over the valuable properties of these alloys, we were led at times to overstep the mark and place such bearings in service where the loads or the impacts were too great.

The first requisite of a bearing is that it shall be sufficiently hard to support its load or to resist the impacts to which it may be subjected, and the relation of tin to lead must be controlled by this requirement. We have sometimes made mistakes in recommending the copper

<sup>1</sup>Int. Franklin Inst. (July, 1903), 156, 195. Proc. Amer. Soc. Testing Materials (1907), 7302. Amer. Inst. Metals (1915), 9241.



65, tin 5, lead 30, alloy for certain mill bearings, but this did not have sufficient resistance to compression, and failed for that reason. When the copper 73, tin 7, lead 20 alloy was substituted the bearings exhibited no deformation and performed far better than the 80-10-10 alloy previously used. We have also noted the failure of the 73-7-20 alloy on rod bearings of very heavy locomotives. Locomotive rod bearings are subjected to severe impacts and it is necessary therefore to use an alloy of fairly high compressive strength. Although the above alloy performs satisfactorily on light locomotives, on the rod bearings of heavy locomotives it is necessary to use either the 80-10-10 alloy or the same alloy to which has been added approximately 1 per cent of phosphorus. The size of these bearings, and hence their bearing surface, is narrowly limited by necessities of construction; otherwise these harder alloys would not be essential for this purpose. Phosphorus greatly increases the compressive strength of such an alloy, and is for this reason a possible factor for conserving tin. At the present prices of tin and phosphorus there is little choice; an alloy with 8 per cent of tin and 1 per cent of phosphorus will have compressive strength approximately equivalent to the alloy having 10 per cent tin. Experience, thus, has demonstrated that alloys containing as little as 5 or even 4 per cent tin and as high as 30 per cent lead, can be used in railroad service for the densest traffic. They have become the standard of the United States Railroad Administration for car-journal bearings called for under their Specifications R-71 Grade A. Such an alloy is also included in the specifications covering locomotive bearings designated as Specification R-72, Soft Bronze.

In my judgment, the specifications of the Railroad Administration covering locomotive bearing-metals are very satisfactory, except that the use of soft bronze should be extended to cover driving brasses, and engine and trailer-truck bearings. Before the Railroads of the United States came under Government control, copper alloys with low-tin and high lead contents had become the standard specifications of several of the large car companies, and were very extensively used on the largest railroad systems. Outside of the railroad field they had also been widely recognized and used. The advantage of using the smallest possible amount of tin consistent with the load requirements is now so well understood that there is but little opportunity for an important conservation of tin in this field.

Let us next consider the possibilities of substituting some other metal for a part or all of the tin in a copper-tin-lead alloy, or of substituting alloys of an entirely different type.

The first metal that presents itself as a substitute for tin is antimony. Antimony combines readily with copper and with lead, and has the property of adding hardness. Unfortunately, however, the hardening effect of antimony is obtained with the sacrifice of ductility. We have found it possible to make alloys carrying as high as 30 per cent of lead with 3 per cent of tin and 2 per cent of antimony. We have also made alloys of 65 copper, 30 lead, 2 tin, and 3 antimony, and have also replaced the 5 per cent of tin in this alloy entirely with antimony. Car bearings 4 1/2 x 8 in. size made from the same pattern and subjected to a breaking stress applied longitudinally at the middle of the back of the bearing

and throughout its entire length, broke at the following average loads: with 2 per cent antimony substitution, 60,000 lb.; with 3 per cent substitution, 62,000 lb.; with total substitution, 52,000 lb.: as compared with a breaking load of 67,000 lb. for the alloy of copper 65, tin 5, lead 30. The castings produced with each of the three above-mentioned alloys are not so satisfactory as those made with the straight tin alloys, being more or less rough, and showing slight globules of lead on the surface. It has been found that a certain amount of nickel can be used for replacing tin with very satisfactory results. The castings produced when zinc is substituted for a certain amount of tin are decidedly unsatisfactory. The substitution of aluminum for tin is entirely impractical, and such castings are worthless. This does not, however, exhaust all the possibilities of substituting other metals for tin in the copper-tin-lead alloys, but it is my opinion that the substitution of any other metals, in those alloys, can be made only by sacrificing the quality of the alloy.

The possibility of substituting alloys of an entirely different type presents an attractive field for research. The copper-tin-lead alloy has attained its position as the most desirable bronze bearing alloy, but this does not mean that some other alloy may not be found which may give equally good or better results. In the search for such a substitute alloy it should be borne in mind that a bearing metal should possess the following properties:

1. It should be sufficiently rigid to support the load or resist the impact, but yet not so brittle that it will easily crack.
2. It should have as great a yielding or plastic nature as is consistent with its ability to support the load or resist the impact without deformation of the bearing as a whole.
3. The ideal structure combines a hard matrix to support the load and a softer metal or alloy contained within such matrix, to permit the bearing surface to adjust itself to irregularities of surface.
4. It should be easy to handle in the foundry and machine shop.
5. It should be capable of being remelted without deterioration.
6. For use in babbitt-lined bearings, it should be capable of being tinned, so that the babbitt can be applied thereto.
7. It should have good heat conductivity in order to dissipate the heat generated by friction.

#### PENNSYLVANIA RAILROAD ANTI-FRICTION AND BELL METALS

Mr. H. M. WARING gave an interesting account of the approximate composition of the non-ferrous alloys in general use on the Pennsylvania Railroad as follows:

|                                   | Copper | Tin    | Lead  | Phos. | Antimony | Zinc |
|-----------------------------------|--------|--------|-------|-------|----------|------|
| Phosphor bronze, spec. 32-c       | 79 70  | 10 00  | 9 50  | 0 80  |          |      |
| Ex. B bronze spec. 141            | 76 75  | 8 00   | 15 00 | 0 25  |          |      |
| Special high lead bronze spec. 59 | 70 00  | 5 00   | 25 00 |       |          |      |
| Lining metal spec. 57             |        |        | 87 00 |       | 13 00    |      |
| Dandelion metal                   |        | 10 00  | 72 00 |       | 18 00    |      |
| Bell metal                        | 83 1/2 | 16 1/2 |       |       |          |      |
| Babbitt, machine                  | 3 70   | 88 00  |       |       | 7 40     |      |
| Babbitt for all bearings          | 1 00   | 50 00  | 38 50 |       | 10 50    |      |

Phosphor bronze is used principally for rod bushings, main-rod brasses, and crosshead shoes.

Ex. B bronze is used to a small extent for backs of car and coach bearings but the majority of these are now made of the car-journal bronze, which contains, on the average, about 5 per cent tin.

Car-journal bronze is used for making car and coach bearing backs at the Altoona brass foundry, by melt-

ing down old backs after removing the linings and making the necessary addition of new metal to bring the composition within the limits containing not less than 71 per cent copper, 4 per cent tin, 13 per cent lead and more than 0.20 per cent phosphorus and 3 per cent zinc. No new tin is added in making this alloy.

Special high-lead bronze is used principally for locomotive driving-box shells, which are not lined.

The lead-base lining for car journal bearings was formerly made up in our foundry from lining metal melted off from old bearings and brought up to specification requirements by the addition of such new metal as might be necessary. Some tin was unavoidably introduced from the old bearings, but the amount allowed in the metal was limited to 2 per cent. Lately we have been using this old lining metal in the preparation of the lead-base dandelion metal babbitt, thus making use of the contained tin in order to reduce the amount of new tin which it was necessary to add to this metal. The journal-lining metal is then made from lead and antimony without the addition of any tin.

Lead-base dandelion metal babbitt, containing about 10 per cent tin, is used for lining cross-head shoes and also for lining engine truck and trailer bearings, as well as for hub liners, in place of phosphor bronze, on freight locomotives. This metal has replaced a large amount of tin and tin-base babbitt formerly used.

Bell metal is used exclusively for making locomotive bells, and during 1917 about 42,800 lb. of castings were made, involving the use of a little over 7000 lb. of tin.

Tin-base babbitt metal (88.9 tin, 3.7 copper, 7.4 antimony) is used for a number of miscellaneous purposes in the shops, but its use has been greatly restricted and every effort is being made to do away with it where possible, and to substitute a lead-base babbitt or a babbitt with 50 per cent tin.

The amount of solder having the composition 50 lead, 50 tin, used by the Pennsylvania Lines East, during 1917, was approximately 100,000 lb. but there is reason to believe that a large portion of this can be replaced by a 60-lead, 40-tin solder with satisfactory results, and instructions have been issued to this effect.

In regard to the quantity of new tin used, it is not possible to give the amount except approximately, and from calculations based on the 1917 consumption of bearing metals by the Pennsylvania Lines East only, it is estimated that about 770,000 lb. of new tin were required in a total of about 21,380,000 lb. of all kinds of bearing metals turned out by the foundry or purchased in the market.

No change has been made in the specifications for bearing metals for some years, as the metals used have been satisfactory. A large proportion of the bearing metals are made up from old material re-melted and brought to standard composition by some addition of new metal, and every effort is being made to utilize old material to the best advantage and reduce the amount of new metal of all kinds purchased. For a number of years no tin has been used in the lining metal of either passenger or freight car journal-bearings, except such small amounts as come in from re-melting old linings. No change has been made in phosphor bronze used for rod bushings, as we should expect some trouble from bushings pounding out of shape if a phosphor bronze

were used which contained less tin or more lead than the present specifications call for. In this, as well as in the case of all other bearing metals, we expect to use our utmost endeavors to economize and to substitute for tin wherever possible.

#### SOLDER, ITS USE AND ABUSE

MR. MILTON L. LISSBERGER gave an excellent account of the properties of lead and tin alloys and the procedure of manufacturing commercial solders as follows:

Solder is a mechanical mixture of tin and lead. This is susceptible of a very quick and simple demonstration.

A bar of solder passed through a buffing machine even of a grade as low as 30% tin and 70% lead will show a surface practically identical with a bar of second quality or reclaimed tin.

The buffings when subject to a chemical analysis will show almost pure lead.

Now then, let us examine the reasons of this. Under the very best practice solder is made by first melting down the virgin pig lead. When the lead is absolutely liquefied virgin pig tin is added and a small amount of flux, the flux being for the purpose of bringing to the surface the so-called liver of metal that may have remained in either the lead or tin through incomplete refining.

The entire material when completely liquid is then thoroughly stirred for some hours. This mixture is next cast into small pigs. Just before casting into pigs, and continuously while this operation is going on, the kettle of molten metal is producing what is commonly called dross, but which in a great measure is actually the oxide of lead and tin, and this should be carefully skimmed off.

After these pigs of metal have been completely cooled, they are taken to a smaller kettle, re-melted and cast into the desired shape for use, or if to be made into wires, ribbons, etc., are cast in slugs suitable for extrusion and rolling.

While this second operation is taking place the skimming of the so-called dross should be, if anything, much more carefully done than when it is being cast into pigs.

Hand mixing has been proven as the only absolutely reliable method for the production of the best quality of solder. This means quality irrespective of the percentages of lead and tin that enter into the solder.

This last statement is made in view of the fact that the best quality of solder does not at all times mean the solder that contains the highest percentage of tin. The best quality of solder, as far as the proportion of lead and tin contents are concerned, is that composition which best performs on the required piece of work.

At this time, it is well to consider what does take place in the mixing of the lead and tin, and why there is a necessity of stirring for such a long period of time.

As stated at the outset, lead and tin do not form an alloy; therefore, to get a mechanical mixture as near perfect as it is possible to do, it is necessary to stir for a long period so as to break up the tin and lead into as small particles as it is possible to do, and to have these particles of lead and tin intermix.

Experience has shown that to perform this operation to the highest degree possible takes between five and

six hours, and this is irrespective as to the quantity of material being mixed.

Further, the difference in time is inappreciable between a mixture high in tin and one low in tin running in a commercial way down from 60 per cent tin to 30 per cent tin.

When the solder is first cast into pigs, and all through the casting process, what takes place is that the tin solidifies in the form of a skeletal mass. In the interstices of this skeleton rest the small globules of lead.

It is remarkable how many shapes these interstices take. The seeming explanation of these various shapes is the amount of other material present than tin and lead; hence very small, in fact it might be called chemical trace of foreign material present in the mixture causes a variation in shape.

To put this plainly, in a mixture made of chemically pure lead and chemically pure tin, the formation of the tin skeleton will differ from a material made where there is so much as one thousandth of one per cent of impurities.

As a further proof of the fact that solder is not an alloy of tin and lead: it would be found on examining the pigs first cast that there has been a segregation of the tin and lead equivalent to about one percent per perpendicular inch of height.

Taking a mixture of 50 per cent tin and 50 per cent lead, and casting it in a block six inches high, examination of scrapings made from the bottom of this block shows a composition of 47 per cent tin, 53 per cent lead. Borings made one inch from the bottom show 48 per cent tin, 52 per cent lead. Borings made two inches from the bottom show 49 per cent tin, 51 per cent lead. Borings made three inches from the bottom show 50 per cent tin, 50 per cent lead. Borings made four inches from the bottom show 51 per cent tin, 49 per cent lead. Borings made five inches from the bottom show 52 per cent tin, 48 per cent lead. Scrapings made from the top show 53 per cent tin, 47 per cent lead.

Now, you may mix as long as you want, but you cannot overcome this segregation provided the liquid solder is cast for the full six inches at one casting. Should, however, you cast one inch at a time into your mold, allowing it to cool before casting the next inch, you will find you are overcoming in a measure this segregation, but there is still a decided difference in the tin contents of the scrapings made from the bottom and the top of the pig.

Mr. Lissberger divided solder into two classes, that which is used strictly for soldering purposes, or the joining and holding together of pieces of metal, and second, that which is used primarily for filling, in which the joining is a secondary consideration.

He thought that the greatest abuse of solder is in the use of high tin mixtures for these filling metals. A mixture of 25 per cent tin and 75 per cent lead worked at the proper heat and with proper fluxing, he declared to be high enough for any filling purpose. This has been demonstrated in the practice of the oil canners, particularly the Standard Oil Co. The best means of conserving solder in can making, it was suggested, is to deepen all baths whether on line machinery or for hand dipping. Overheating of the baths should be avoided and the top of all baths covered with a pro-

tecting material, as sal ammoniac, oil, charcoal or ash.

Mr. Lissberger lamented the great waste of tin in the failure of many plants to save their dross. He gave his opinion that a 46 parts tin, 54 parts lead and  $\frac{1}{2}$  part antimony makes the strongest solder, though for machine work, as low as 38 per cent tin has given satisfaction. Later during a discussion before the meeting, Mr. Lissberger spoke at length concerning the substitution of cadmium for tin in solder and was very emphatic in stating the defects of this type of solder, though he did not specifically denounce the new 80-10-10 solder.

#### THE TIN-PLATE INDUSTRY

MR. STONE read the following from the paper of Mr. M. D. BUCK: During the first 5 months of 1918, approximately 11,000,000 lb. per month of pig tin were consumed in the United States. Solder bearing metals, bronzes, etc., used about 5,500,000 lb.; collapsible tubes a little more than 250,000 lb.; tin-foil about 500,000 lb.; and the tin- and terne-plate industry somewhat less than 5,000,000 lb. In an effort to reduce this consumption and thus conserve our tin supplies, several methods of procedure suggest themselves:

1. Salvage. The most careful and systematic collection and re-use of tin and tin-bearing materials is economically important, in that we thus secure the maximum benefits from our available supplies.

2. Substitution of other materials for tin. While tin, on account of its low melting point, softness, malleability, non-toxicity etc., is peculiarly adapted for many uses, nevertheless it may seem desirable, during times of temporary stringency at least, to substitute for tin and for tin-bearing materials some other substances which may answer our purposes, though perhaps not possessing all of the desirable qualities of tin. It is conceivable that research in this connection may develop entirely satisfactory substitutes which may permanently replace tin for certain purposes.

3. Curtailment, for the time being, of certain lines of manufacture, not absolutely essential to the prosecution of the war.

Efforts along all of the above-mentioned lines are being made in practically all tin-consuming industries, and much progress has been made. In considering the details of tin conservation, it is my intention to confine myself to a brief discussion of this subject as related to the tin- and terne-plate industry.

Terne-plate is a mild-steel sheet coated with an alloy of tin and lead (approximately 25 per cent tin and 75 per cent lead). Its chief uses, in normal times, are for roofing, gasoline and oil tanks, and for stamping into various forms. Manufacturers of this material have almost entirely discontinued its manufacture, except to supply the urgent needs of the Government for war purposes.

It has been customary to use a small amount of tin with the spelter in the galvanizing pots in the manufacture of galvanized sheets. It has been found that, by a sacrifice of no other quality than appearance, this tin could be omitted, and the practice has been largely discontinued—entirely so in the concern with which the writer is connected.

Tin-plate consists of thinly rolled mild-steel sheets coated with pure tin, and its chief use is in the canned-



food industry. The Government has requested that the manufacturers of this product give absolute priority to orders covering material to be used for the manufacture of plate for cans to contain perishable foods. The manufacturer has, of course, complied with this request and the conditions of the markets have been such that almost the entire capacity of the country has been utilized for such material and for other direct and indirect Government needs.

Several grades of tin-plate are regularly manufactured, differing only in thickness of the tin coating. While for some few uses the heavier coated sheets are desirable and necessary, it is a fact that the most lightly coated sheets are entirely suitable for a very large percentage of these requirements. It is in this connection that the consumer can materially aid in the saving of tin during the present stringency, and also prevent a serious economic waste in normal times, by not specifying a heavier coated plate than his requirements justify.

For years it was believed by certain canners, manufacturers, and dealers in canned goods, that a heavy tin coating was necessary on food containers. This opinion was endorsed by food officials and chemists, and attempts have been made in Congress to regulate the weight of tin coating. Since the literature on the subject gave no definite information, a committee was formed several years ago, consisting of representatives of the American Sheet and Tin Plate, American Can, and the National Canners' Association two representatives of the Bureau of Chemistry, Department of Agriculture, also participated in the work. This committee prepared seven lots of tin-plate with the following average coatings, expressed in pounds of tin per base box (112 sheets, 14 by 20 in.).

|         |         |         |         |
|---------|---------|---------|---------|
| A ..... | 0.9 lb. | E ..... | 1.8 lb. |
| B ..... | 1.1 lb. | F ..... | 2.1 lb. |
| C ..... | 1.3 lb. | G ..... | 3.0 lb. |
| D ..... | 1.5 lb. |         |         |

Cans were made from these plates in the usual way, and various food products were packed under the supervision of the committee, in regular canning plants.

The cans and contents were inspected and analyzed from time to time, throughout a period of about 18 months after filling the cans. In this work more than 40,000 samples were analyzed chemically. I quote from the general conclusions of this committee as embodied in their report:

"The most significant fact established by this entire investigation is that, aside from the external appearance of the cans, none of the difficulties encountered in the twenty experimental packs of twelve representative foods in plain cans was taken care of or eliminated by heavy tin coatings. . . . The luster and the resistance to rusting increase somewhat with increased weights of coating. In other respects, with the exception of some instances in those classes of foods that have a tendency to perforate, the conclusion from this work is that the value of different weights of tin coating on food containers is for all practical purposes the same with average weights of from one to three pounds of tin per base box."

I bring this investigation to your attention to emphasize the needless waste attendant upon the use of tin plate with an unnecessarily heavy tin coating. With our

present knowledge, we are unable commercially to produce coatings as light as the lower weights used in this test. If, however, future research should develop means to this end the resultant product would meet all practical requirements, and a very considerable saving in pig tin would result.

#### THE BUREAU OF STANDARDS INVESTIGATIONS

DR. PAUL D. MERICA presented the paper by MESSRS. G. K. BURGESS and R. W. WOODWARD, from which the following are extracts:

"There is no question but that the tin content of nearly all bearing metals can be reduced to some extent, and in some cases actually eliminated without prejudice to the service rendered. So the problem is to determine what needs are the most exacting, or when a breakdown would cause the greatest damage and confine the use of high tin babbitts to these uses only. Thus the main bearings of airplane and military automobile engines, turbine shafts, etc., will probably have to continue to use high tin babbitt with a tin content of from 84 per cent to 91 per cent. A babbitt metal such as S. A. E. specification No. 24 containing 84 tin, 9 antimony and 7 copper appears to be as satisfactory in service as one such as genuine babbitt, 89 tin, 7½ antimony, 3½ copper, or that specified by the International Aircraft Standards Board, 91 tin, 4½ antimony and 4½ copper; but it should be pointed out that the latter two compositions are more fluid in the molten condition than the first named and consequently the lining can be made in a thinner shell with these babbitts and the total amount of tin consumed may therefore be less than if the S. A. E. No. 24 was used. However, if the design of the bearing is not altered to admit of the thinner shell, the lower composition babbitt should be used in general.

The following compositions are also recommended for use where a high grade of lining is required and when a genuine babbitt is often now used:

|           | No. 1    | No. 2 | No. 3 | No. 4 | No. 5 | No. 6 |
|-----------|----------|-------|-------|-------|-------|-------|
| Tin       | 65       | 62    | 8     | 5     | 10.0  | 21.3  |
| Antimony  |          |       | 8     | 7     | 12.5  |       |
| Copper    |          |       | 4     | 2     | 0.5   | 3.0   |
| Zinc      | 28 to 30 | 33    |       | 76    |       | 63.3  |
| Aluminium |          | 1     |       |       |       |       |
| Lead      |          |       | 80    | 10    | 77.0  | 12.0  |

Nos. 3 and 4 have been found to do the service required of tin base linings in machine tool bearings; No. 5 can be used on similar bearings where a greater strain is met. No. 6 is in use in Germany as a "best" babbitt to conserve both tin and copper.

For linings on railroad truck journals two compositions are in general use, one composed of 85 lead, 10 antimony, 5 tin, and the other of 87 lead and 13 antimony. The latter is restricted by some roads to freight service and the former used on passenger equipment. Many roads, however, use the 87 lead and 13 antimony on both classes of service and it seems that its use might be made more universal.

Another type of lining metal which deserves serious consideration is one composed almost entirely of lead with small additions of alkali or alkali earth metal. Certain of these have been given service tests at the Bureau of Standards and in many respects were found equal to or superior to genuine babbitt.

Following is a summary of the tests on the metal and

similar tests on genuine babbitt of composition 89 tin, 7½ antimony, 3½ copper:

## Genuine Babbitt

| Lead, lb. per cu. in. | R. P. M. | Total No. of Revolutions | Final Temp. °C | in 12" Temp. °C | Rise Temp. °C | Friction Weight 1 lb. Gram | Loss in Weight 0.023 | Remarks |
|-----------------------|----------|--------------------------|----------------|-----------------|---------------|----------------------------|----------------------|---------|
| 200                   | 706      | 16,310                   | 102            | 216             | 58            | 104                        | 29                   | 0.021   |
| 300                   | 682      | 15,150                   | 125            | 257             | 100           | 180                        | 38                   | 0.013   |
| 400                   | 603      | 6,600                    | 139            | 282             | 94            | 169                        | 79                   | 0.054   |

Belt slipping. Bearing seized and smoking

## ULC HARD METAL

| Lead, lb. per cu. in. | R. P. M. | Total No. of Revolutions | Final Temp. °C | in 12" Temp. °C | Rise Temp. °C | Friction Weight 1 lb. Gram | Loss in Weight 0.023 | Remarks |
|-----------------------|----------|--------------------------|----------------|-----------------|---------------|----------------------------|----------------------|---------|
| 100                   | 710      | 13,160                   | 56             | 133             | 23            | 41                         | 13                   | 0.013   |
| 100                   | 715      | 18,370                   | 69             | 156             | 33            | 59                         | 18                   | 0.021   |
| 300                   | 719      | 18,830                   | 80             | 176             | 42            | 76                         | 27                   | 0.013   |
| 400                   | 711      | 17,310                   | 81             | 178             | 43            | 77                         | 25                   | 0.022   |
| 500                   | 723      | 17,660                   | 79             | 174             | 43            | 77                         | 25                   | 0.014   |
| 600                   | 692      | 14,960                   | 84             | 183             | 45            | 81                         | 24                   | 0.021   |
| 700                   | 648      | 24,320                   | 62             | 144             | 38            | 68                         | 24                   | 0.020   |
| 800                   | 365      | 12,870                   | 53             | 127             | 20            | 36                         | 23                   | 0.010   |
| 900                   | 408      | 22,300                   | 59             | 138             | 22            | 40                         | 24                   | 0.015   |
| 1000                  | 405      | 23,200                   | 66             | 151             | 36            | 65                         | 22                   | 0.014   |

Bearing still good condition.

## STANDARD GRADES OF BABBITT METAL

At a meeting called by the Conservation Division of the War Industries Board on April 15, 1918, which was attended by manufacturers and users of bearing metals, the Bureau of Standards was requested after conference with technical representatives of the large manufacturers and users, to determine if four classes of babbitt metal could be adopted ranging in tin content as follows:

A—Genuine babbitt, 89 per cent tin.

B—Genuine babbitt, 40 to 50 per cent tin.

C—Genuine babbitt, 4 to 6½ per cent tin.

D—Genuine babbitt, no tin.

The bureau has gone over the situation with several of the representatives and the general opinion seems to be that it is impossible to limit some of the classes to a single composition, because of the fact that several compositions of nearly the same tin content are in general use for different purposes. Thus in the table below No. A1 is used in aircraft engines, No. A3 is used for automobile engines, No. A4 is found in bearings of electrical machinery. It was thought, however, that class B can be entirely dispensed with, as these intermediate tin content bearing metals are in no way as satisfactory as either a high lead or high tin base babbitt. In all cases where class B could be used, class C or class D will be found to serve the purpose equally as well. There are, however, some grades of babbitt containing about 65 per cent of tin which do not fall into either class A or class B, but which are often claimed by the manufacturers to equal the high tin babbitt in performance. If these claims can be substantiated this babbitt should be considered as falling into the category of class A and as being a substitute for alloys in that class.

It should not be presumed, because high tin babbitt of class A is included, that the bureau recommends the continuance of its use for many bearings in which it is now used. The lowest possible tin content alloy should always be used, and the bureau believes that it might be advisable to leave some central body issue license for the use of babbitt in class A in order to insure that no class A babbitt is being used where others are satisfactory.

Alloy D2 has been included in class D because this comprises babbitt metals containing no tin. It should be noted, though, that this alloy will be found satisfactory in many installations where class A has hitherto

been used and its inclusion in class D should not give the impression that it is a low grade babbitt.

The American Society for Testing Metals has drawn up specifications for twelve compositions of babbitt metals (B23-18T) which, however do not take into consideration the factor of tin conservation, but are formed for use in peace times. The present recommendations are for use in the existing situation, where the saving of all tin possible is of prime importance.

The recommended compositions for the various classes are given in the table below. These compositions have been selected so as to include existing specifications and usage of babbitt metals as far as possible. Much information has been secured from the questionnaire sent out by the bureau and from replies to the general letter issued by the War Industries Board on May 29, 1918.

| Class | No. | Tin Per Cent                 | Antimony, Per Cent                   | Lead, Per Cent | Copper, Per Cent | Iron, Max. | Arsenic, Max. |
|-------|-----|------------------------------|--------------------------------------|----------------|------------------|------------|---------------|
| A     | A 1 | 91                           | 41                                   | 1 00 a         | 41               | 0 08       | 0 10          |
|       | A 2 | 89                           | 71                                   | 1 00 a         | 31               | 0 08       | 0 10          |
|       | A 3 | 84                           | 9                                    | 1 00 a         | 7                | 0 08       | 0 10          |
|       | A 4 | 83                           | 81                                   | 1 00           | 81               | 0 08       | 0 10          |
| C     | C 1 | 5                            | 10                                   | 85             | 0 50 a           | ..         | 0 20          |
| D     | D 1 | 13                           | 37                                   | 0 50 a         | ..               | ..         | 0 25          |
|       | D 2 | Lead about 98%<br>a Maximum. | balance alkali and for alkali earth. | ..             | ..               | ..         | ..            |

More than traces of impurities other than those listed above will not be allowed; the following variations above or below the specified amount will be permissible for the desired elements:

| Percentage of Elements Specified | Permissible Variations Over or Under the Specified Value Units of Per Cent. |
|----------------------------------|-----------------------------------------------------------------------------|
| Not over 5 per cent.             | 0 50                                                                        |
| 5 to 10 per cent, incl           | 0 75                                                                        |
| Over 10 per cent                 | 1 00                                                                        |

Large quantities of phosphor bronze of the compositions 80 copper, 10 lead, and 10 tin are dioxided with phosphorus, are used in unlined bearings at fairly high speeds and pressures. The following compositions have been suggested as substitutes for phosphor bronze, although it is our opinion that trouble will sometimes be experienced with Nos. 8, 9 and 10, because of the high lead content, although they have about the same tin content as the others in the list.

|                 | No. 7 | No. 8 | No. 9 | No. 10 | No. 11    | No. 12    |
|-----------------|-------|-------|-------|--------|-----------|-----------|
| Copper          | 81    | 79    | 74    | 64     | Remainder | Remainder |
| Tin             | 7     | 3     | 5     | 5      | 15        | 17 5      |
| Lead            | 9     | 15    | 20    | 25     | 15        | 17 5      |
| Zinc            | 3     | ..    | ..    | ..     | 1 5-3 0   | 5 0       |
| Antimony        | ..    | ..    | ..    | ..     | ..        | ..        |
| Phosphor Copper | ..    | 1     | 1     | ..     | ..        | ..        |

## STRUCTURAL BRONZES

Passing now to the bronzes other than those for bearing purposes, we find that "Government Bronze" (Navy Specification, 46M6a, Gun Metal) or 88 copper, 10 tin, and 2 zinc, is used in large quantities and can also be modified to admit of a saving of tin without impairment of the physical properties sought. Experiments by the Bureau of Standards and others have shown that a composition of 88 copper, 8 tin, and 4 zinc, is equal to or superior to the ordinary Government bronze. Aluminium bronze of composition 90 aluminium, 10 copper, for example, can also be substituted for many uses of Government bronze as can also manganese bronze and naval brass. There have also been introduced several aluminium bronzes containing small amounts of iron, which can be either cast or wrought, and which are now being used by several former users of Government bronze.

Some manufacturers have raised an objection to using aluminium bronze because the scrap accumulating from this alloy, if it gets mixed with other metals, particularly value metals, would have a deleterious effect upon them. This is simply a problem in works management of properly sorting and routing scrap. We know of several large manufacturers who make aluminium bronze castings in the proximity of steam metal castings and who by taking the proper precautions have encountered no difficulties.

The following table gives some of the properties of the above mentioned alloys:

| Alloy                                                 | Tensile Strength<br>Lb.<br>Sq. In.           | Elastic Limit<br>Lb.<br>Sq. In. | Elongation<br>in 2 In.<br>Per<br>Cent. | Authority                                                                                                       |
|-------------------------------------------------------|----------------------------------------------|---------------------------------|----------------------------------------|-----------------------------------------------------------------------------------------------------------------|
| Government<br>bronze 88 Cu<br>10 Sn, 2 Zn...          | 38,860                                       | 12,250                          | 25.2                                   | Average of 30 tensile specimens poured in 5 different foundries. Tensile tests made at the Bureau of Standards. |
| 88 Cu, 8 Sn, 4 Zn                                     | 39,220                                       | 11,000                          | 30.6                                   | Same as above, except that it only represents 26 specimens.                                                     |
| Aluminium bronze                                      | 71,000                                       | 25,000                          | 21                                     | Corse & Comstock Trans. Soc. Autom. Eng., 1916, part 11 p. 272-73.                                              |
| Manganese bronze,<br>U. S. N., Mn...                  | 70,000                                       | 35,000                          | 30                                     | Navy Department Specification 46-B15.                                                                           |
| Naval brass...                                        | 54,000<br>over 1 in.<br>60,000<br>below 1 in | 25,000<br>27,000                | 40<br>35                               | Navy Department specification 46B-6b.                                                                           |
| Aluminium<br>bronze with<br>iron (Sillman<br>bronze): |                                              |                                 |                                        | Bureau of Standards Test.                                                                                       |
| Wrought alloy                                         | 84,400                                       | 14,000                          | 11.5                                   |                                                                                                                 |
| Cast Alloy...                                         | 78,850                                       | 11,500                          | 14.5                                   |                                                                                                                 |
| Chemical composition Cu                               |                                              |                                 | 86.4 per cent.                         |                                                                                                                 |
| Chemical composition Al                               |                                              |                                 | 9.7 per cent.                          |                                                                                                                 |
| Chemical composition Fe                               |                                              |                                 | 3.9 per cent.                          |                                                                                                                 |

#### CADMIUM AS TIN SUBSTITUTE IN SOLDER

Cadmium appears as a promising substitute for part of the tin in solders. The bureau has been developing such a solder, and laboratory test together with manufacturing experience so far point to a composition of 80 lead, 10 tin and 10 cadmium as being practical for many of the purposes for which solder is required. This solder has been tried in the manufacture of tin cans, on roofing materials, and for electrical joints with encouraging results in all cases. Before using it for food containers, however, it will be necessary to ascertain its toxic properties under various conditions. A test has also been made of it in the manufacture of automobile radiators with most satisfactory results.

The tensile strength of the cadmium solder is about the same as that of 40-60 solder, but the ductility is approximately twice that of the ordinary solders. The point of complete liquation is only slightly higher than that of the ordinary composition of solders, while the range of solidification is considerably greater. Table I gives some of the provisional data on these solders as compared to the tin-lead solders; the tensile properties given are the average of four determinations and even made on a Scott testing machine, the rate of separation being about twelve inches per minute.

Because of the preponderance of lead in the cadmium solder, the price of it is very reasonable; with the present market prices of the metals involved it is thought that the 80-10-10 solder can be sold at a profit at 35 cents a pound. It is also thought that plenty of cad-

mium can be produced as soon as the market of it is created as there are undoubtedly available American sources of cadmium which are not at present exploited.<sup>2</sup>

In meetings with manufacturers of materials containing tin it is always brought out that the Government is the worst offender, and that many Government

TABLE I. PHYSICAL PROPERTIES OF CADMIUM-LEAD AND TIN-LEAD SOLDERS

|                           | Initial Solidification,<br>Deg. C. | Secondary Solidification,<br>Deg. F. | Final Solidification,<br>Deg. C. | Specific Gravity | Equivalent Volume<br>to 1 Volume, 50-50<br>Solders | Tensile Strength,<br>Lb. per Sq. In. | Elongation in 2" in<br>Cent |
|---------------------------|------------------------------------|--------------------------------------|----------------------------------|------------------|----------------------------------------------------|--------------------------------------|-----------------------------|
| 50 tin-50 lead...         | 210*                               | 181*                                 | 149*                             | 8.81             | 1                                                  | 5,698                                | 20.3                        |
| 40 tin-60 lead...         | 238*                               | 181*                                 | 149*                             | 9.47             | 1.07                                               | 5,820                                | 26.0                        |
| 37 1/2 tin-62 1/2 lead... | 245*                               | 181*                                 | 149*                             | 9.54             | 1.08                                               | 5,383                                | 28.6                        |
| 90 lead-10 cadmium...     | 267*                               | 249*                                 | 249*                             | 11.09            | 1.26                                               | 5,000                                | 37.5                        |
| 80 lead-10 cadmium-10 tin | 254                                | 183                                  | 143                              | 10.35            | 1.17                                               | 5,727                                | 52.3                        |
| 85 lead-10 cadmium-5 tin  | 257                                | 202                                  | 141                              | 10.67            | 1.21                                               | Not determined                       |                             |
| 75 lead-10 cadmium-15 tin | Not determined                     | Not determined                       | 10.26                            | 1.16             | 5,880                                              | 41.7                                 |                             |

\* Rosenhain and Tucker, Phil. Trans., A. 209, 1918, p. 89.  
\* Kapp, Drudes Ann., 6 754 (1901).

specifications often call for a lavish use of tin which is sometimes detrimental to the quality of the material manufactured. We believe, however, that many of these specifications are being revised in order to conserve tin, but that there is still room for further improvement. As a means of conserving the use of tin by the Government, we would suggest the advisability of creating a joint committee of technical representatives of the various departments to pass upon or revise all Government specifications containing tin. Such a committee could be in close co-operation with the manufacturers and would form a better means for the manufacturers to criticise the tin content of Government specifications than now exists in any of the departments.

#### OTHER TOPICS IN BRIEF

MR. J. L. JONES of the Westinghouse Electric & Manufacturing Co. stated that his company had found that a lead based babbitt of 78 per cent lead, 14 antimony and 8 tin was suitable for all types of electrical machinery. This alloy has a Brinnell hardness of 27 to 28, pours well and is tough and clean. Great care must be taken in its preparation to prevent segregation etc. Furthermore many babbitt linings are being made  $\frac{3}{16}$  inch in place of  $\frac{1}{8}$  inch. He described a special solder pot for melting babbitt metal which his company has found very advantageous, in that a complete separation of the accompanying oxides is obtained, making clean castings as well as economizing materials.

MR. W. M. CORSE of the Titanium Bronze Co. gave an excellent paper on aluminium bronze which pointed out the excellence of this type of alloy. This paper will be published separately in the near future.

MR. H. D. EGBERT of the Research Corporation pointed out the applicability of electric dust precipitation of the tin vapors at the sash weight foundry cupolas, where old tin cans, etc., are melted up. The development of this field promises a very important recovery, as there need not be a very great expenditure in cleaning off labels, etc., from the cans, which can be crushed, dried and smelted.

<sup>2</sup>See C. E. Liebenthal, Cadmium in 1917, Mineral Reserves of U. S., 1917, Part 1, 49-53.



# Calculation of Extraction in Continuous Agitation

Derivation of a Mathematical Formula for Continuous Systems of Extraction in Hydrometallurgy and Industrial Chemistry — Examples of Application — Modifications for Non-Homogeneous Material and Where Complete Reaction is Required

BY ANDREW HAM AND HARRISON STREETER COE

**EDITOR'S NOTE.**—The accompanying article has for its basis a paper offered for publication by Mr. Andrew Ham on the mathematical relation between the efficiency of continuous and intermittent agitation.

The deductions seemed to be of unquestionable value, but the mode of presentation, which included the derivation of the formula by calculus, seemed somewhat too intricate. With Mr. Ham's approval we invited the co-operation of Mr. H. S. Coe, who confirmed the correctness of the premises and the computations. He has also presented the formula in a different manner, with Mr. Ham's tables modified to be directly applicable in designing continuous agitation plants and determining the losses to be expected therefrom. Mr. Coe further discusses various features not touched on by Mr. Ham and gives a method for making simple tests which will show the relation between continuous and intermittent agitation of ores containing difficultly treated fine sand.

For those desiring to follow the derivation of the formula, Mr. Ham's calculations are appended.

## INTRODUCTION

**I**N THE fields of hydrometallurgy and industrial chemistry, wherever chemical reactions are accelerated by mechanical agitation, the tendency, during recent years, has been to replace the primitive intermittent charge-agitation method by continuous agitation.

Economy of operation has been the principal incentive to this change; and where the nature of the reactions permit, it is generally conceded that continuous agitation has a tremendous advantage over the old method. No one, as far as we are aware, has thus far made public any exact analysis of what physically occurs in a continuous-agitation system, so that treatment by this method can be compared to that in an intermittent-agitation tank. A formula for doing this has been derived by Mr. Andrew Ham and is submitted and explained in Part I of this article.

The method presented for applying the formula differs from that offered by Mr. Ham, but otherwise Part I of this article is a presentation of his formula explained as simply as possible. It follows his own reasoning quite closely, eliminating the somewhat involved mathematical derivation, which is given at the end of the article.

In Part II Mr. Coe offers a discussion of the application of the formula and of some features which modify its use. Conclusions are drawn relative to the use of the formula.

## I. DERIVATION AND EXPLANATION OF FORMULA

In general, the difference between the operation of intermittent and continuous agitation may be stated as follows: Whereas in the former method the vessel in which a process takes place has to be filled (and

closed under special conditions where heat, pressure, etc., are required) and later emptied at the completion of the treatment, the continuous-agitation system provides a series of vessels (or sometimes only one) in which the material to be treated enters and leaves the system in an uninterrupted stream or at regular intervals. The essential difference in the treatment is that in continuous agitation new material is mixed with material which already has been subjected for some time to the process. Different parts of the material are thus in different stages of treatment, or of different "age," and the material passing out of the system comprises particles which have been subjected to agitation for different periods of time.

It is to determine this "detention" or treatment period which different percentages of the material have had on leaving a continuous-agitation system that the formula given hereafter has been derived.

To establish the formula, a small part of the material which enters a continuous-agitation system in a negligible interval of time is considered; and the proportion of this part remaining in the system after the lapse of any given interval of time is determined.

The small part is called  $a_0$ . The quantities  $v_1, v_2, v_3$ , etc., represent the fractions of  $a_0$  remaining in the first vessel, second vessel, third vessel, etc., of the system after an interval of time  $T$  rated from the entrance of  $a_0$  into the first vessel.

$V_1, V_2, V_3$ , etc., represent the fractions of  $a_0$  remaining in the first vessel, first two vessels, first three vessels, etc.; and if the total number of vessels in the continuous-agitation system be  $n$ ,  $V_n$  represents the fraction of  $a_0$  remaining in the whole system after time  $T$ ; i.e., the fraction of  $a_0$  which has been treated for time  $T$ .

It will be noted that  $V_1 = v_1$  (and where  $n = 1$ ,  $V_n = V_1 = v_1$ ),  $V_2 = v_1 + v_2$ ,  $V_3 = v_1 + v_2 + v_3$ , and  $V_n = v_1 + v_2 + v_3 + \dots + v_n$ . Since every portion of the entering material has the same experience in passing through the system, the numerical values of  $v_1, v_2, v_3$ , etc., and  $V_1, V_2, V_3$ , etc., apply to all of the material agitated. Thus, if  $T$  is 1 hour and  $v_1$  is 0.5 and  $v_2$  is 0.1,  $V_2$  will be 0.6 which means that 50 per cent of the material entering the continuous-agitation system receives 1 hour of agitation in the first vessel and 60 per cent receives 1 hour of agitation in the first two vessels. If the continuous-agitation system contains only two vessels,  $V_2$  will be  $V_n$ . The  $v_2$  or 10 per cent found in the second vessel is made up of particles which have received part of their treatment in the first and part in the second vessel, each with a total of 1 hour of agitation.

With all vessels of equal volume in the continuous agitation system the formula for  $v_1, v_2, v_3$  is  $v_1 =$

$$e^{-zT}, v_2 = \frac{zT}{1} e^{-zT}, v_3 = \frac{z^2 T^2}{2} e^{-zT}. \text{ The general formula is}$$

$$v_n = \frac{z^{n-1} T^{n-1}}{1.2.3 \dots (n-1)} e^{-zT}$$

where  $n$  is greater than 1. In this formula  $e = 2.71828$  (the natural base of logarithms),  $z$  depends on the size of the vessels and the rate of inflow of the substance

and is equal to  $\frac{\text{rate of inflow}}{\text{capacity of vessel}} = \frac{1}{\text{time to fill the vessel}}$

or  $\frac{R}{C}$  where  $R$  = rate of inflow and  $C$  = capacity of vessel.

Since  $V_n = v_1 + v_2 + v_3 + \dots + v_n$ , we have, by giving  $v_1, v_2, v_3$ , etc., their proper value, the general value for  $V_n$  which is,

$$V_n = e^{-zT} \left( 1zT + \frac{z^2 T^2}{2} + \dots + \frac{z^{n-1} T^{n-1}}{1.2.3 \dots (n-1)} \right).$$

Values of  $V_n$  from  $V_1$  to  $V_7$  are given in Table 1, for varying values of  $zT$  and will help to analyze the treatment received in continuous-agitation systems of from 1 to 7 tanks.

Mr. Coe has added column  $B$  to facilitate the use of the table.

In column  $zT$ ,  $z$  is assumed to be a constant for the problem considered, such that the inflowing material just fills one tank in the continuous-agitation system in the time required to treat it by intermittent agitation;  $zT$  therefore becomes  $\frac{\text{time agitated}}{\text{time required}}$ . This column

helps to compare directly the treatment in an intermittent-agitation tank with that in continuous-agitation systems comprising tanks of the same size as the intermittent-agitation tank; and as hereafter shown may be used indirectly in comparing treatment in an intermittent-agitation tank with continuous agitation systems made up of tanks of other sizes.

In column  $B$ ,  $T$  is taken as a constant for the problem considered;  $T$  being a given required period of agitation by intermittent agitation. In this case,  $RT$ , the quantity of material entering the continuous-agitation system in time  $T$ , equals the volume of an intermittent-agitation tank required to treat  $RT$  units of material in time  $T$ . The numerical values given in column  $B$  represent the ratio between the size of each tank in a continuous-agitation system and that of the required intermittent-agitation tank to treat the same quantity of material (assuming the latter to work without lost time, which is of course impossible).

#### EXAMPLES OF USE OF TABLE

If we consider a homogeneous substance to be treated we may compare the size of tanks in the continuous-agitation systems necessary to give required results, to that of an intermittent-agitation tank doing the same work.

*Example 1.* Let us say arbitrarily that 98 per cent of the material must be agitated for the full period of time required by intermittent agitation.

In column  $B$  of the table,  $T$  is assumed to be this full period, and we may note that

In a continuous-agitation system where  $V_1 = .98, B = 50.0$   
In a continuous-agitation system where  $V_2 = .98, B = 1.0$   
In a continuous-agitation system where  $V_7 = .98, B = 0.379$  (by interpolation)

In other words, to give full treatment to 98 per cent of the material by continuous agitation requires a continuous-agitation tank 50 times as large, a four-tank continuous-agitation system with each tank of the same volume, a seven-tank continuous-agitation system with each tank of 0.379 the volume of the required intermittent-agitation tank.

*Example 2.* Comparison of treatment in a three-tank continuous-agitation system with that in an intermittent-agitation tank of the same volume as each continuous-agitation tank and treating the same quantity as the continuous-agitation system. In column  $A$  of the table the fractions of the total treatment period are given and in column  $V$ , the fractions of the material receiving these fractions of the treatment period are shown.

Thus 0.999 remains in the continuous-agitation system for 0.2 full periods  
0.977 remains in the continuous-agitation system for 0.6 full periods  
0.920 remains in the continuous-agitation system for 1.0 full periods  
0.809 remains in the continuous-agitation system for 1.5 full periods

The fraction of the total soluble substance dissolved during the passage of the material through the continuous-agitation system is as follows:

Between 1.000 and 0.999 of total soluble by agitation between 0 and 0.2 full periods  
+ Between 0.999 and 0.977 of total soluble by agitation between 0.2 and 0.6 full periods  
+ Between 0.977 and 0.920 of total soluble by agitation between 0.6 and 1.0 full periods  
+ Between 0.920 and 0.809 of total soluble by agitation between 1.0 and 1.5 full periods

By taking the fractions of the agitation period closely together, a close estimate of the fraction of the total solubles dissolved may be reached.

*Example 3.* Comparison as in example 2 where the continuous-agitation tanks are not equal in volume to the intermittent-agitation tank required.

In this case multiply the numerical value given in column  $zT$  by the ratio,

$$\frac{\text{volume of tank in continuous agitation system}}{\text{volume of intermittent agitation tank}},$$

Thus if we are comparing a continuous-agitation system where the volume of each tank equals one-half the volume of the required intermittent-agitation tank the fraction of the treatment period given in column  $zT$  must be multiplied by one-half and the results for a three-tank continuous-agitation system would be

0.999 remaining in system for 0.1 full periods  
0.977 remaining in system for 0.3 full periods  
0.920 remaining in system for 0.5 full periods  
0.809 remaining in system for 0.75 full periods  
0.676 remaining in system for 1.00 full periods  
0.423 remaining in system for 1.50 full periods

The fraction of the total soluble substance dissolved during the treatment should be:

Between 1.00 and 0.999 of total soluble by agitation between 0 and 0.1 full periods  
+ Between 0.999 and 0.977 of total soluble by agitation between 0.1 and 0.3 full periods  
+ Between 0.977 and 0.920 of total soluble by agitation between 0.3 and 0.5 full periods  
+ Between 0.920 and 0.809 of total soluble by agitation between 0.5 and 0.75 full periods  
+ Between 0.809 and 0.676 of total soluble by agitation between 0.75 and 1.00 full periods  
+ Between 0.676 and 0.423 of total soluble by agitation between 1.00 and 1.50 full periods

The fractions of substance soluble during the fractional periods indicated are to be taken from extraction tests made by intermittent agitation.

## II. APPLICATIONS OF FORMULA

Mr. Ham's formula applies directly to designing continuous-agitation plants, using laboratory tests by intermittent agitation as a basis, provided the material to be agitated is homogeneous; i.e., uniform in size and weight of particles, and if the solvent is maintained at practically the initial strength throughout the treatment.

Where the solids to be agitated contain particles of varying size and weight the use of the formula may be changed due to the concentration of coarse material in the tanks of the continuous-agitation system.

In agitators where the contents are kept in violent motion, there is no chance for such concentration and the formula applies directly, since the material as a whole remains homogeneous. In another type of agitation, such as the Dorr, there is abundant opportunity for concentration of the heavier particles, since the material simply settles to the bottom of the tank to be collected and elevated (together with solution) to the surface by means of an air-lift and redistributed over the tank. When operation is started, the first tank acts therefore as a sand trap. The sand collected from the inflowing material increases until an equilibrium is reached; after which the sand in the material passing over to the second tank will be in the same proportion as in that entering the system.

If we assume that the soluble substance most slowly dissolved is in the sand, which is nearly always true, and that the sand in the tanks is concentrated to, let us say, four times its concentration in the inflow, then relative to the sand treatment each Dorr agitator in the system acts as a tank four times as large as would be indicated by its actual volume; except that the sands so concentrated are not continuously treated with the same solution but receive constantly a fresher solution which accompanies the slimy parts of the ore in its more rapid passage through the system. In other words the feed to the system is of one dilution but the agitation proper is effected on a denser pulp with the effect of constantly adding fresh solution.

Thus in example 3, the percentage of soluble substance dissolved would be raised to

+ Between 1.00 and 0.999 of total substance in sand soluble between 0.2 and 0.4 full periods  
+ Between 0.999 and 0.977 of total substance in sand soluble between 0.4 and 1.2 full periods  
+ Between 0.977 and 0.920 of total substance in sand soluble between 1.2 and 2.0 full periods.

With tanks each one-half the size of the intermittent-agitation tank required showing such complete treatment, it appears quite probable that the total volume in the continuous-agitation system might be equal to or less than that of the required intermittent-agitation tank and yet give better extraction than the latter. Results from practice confirm this view.

### MODIFICATION NECESSARY IN SPECIAL CASES

Another case where it seems necessary to modify the use of the formula is where a complete reaction is required in the system, the solution to be neutralized as well as the substance to be dissolved. The strength of solution in each tank may be computed from the table, provided the rate of reaction of solution of blended strengths on blended fresh and partly treated material is the same as when the relative fractions of the solution and material are agitated alone. It would appear that a

relation between these rates might be established by laboratory tests, and Mr. Ham's formula would then become useful for this case.

## CONCLUSIONS

From the foregoing explanation and the treatment features noted in Part II it is Mr. Coe's conclusion that Mr. Ham's formula is directly applicable in a limited number of instances but that its chief value lies in the fact that it gives a method to study the history of the material in passing through a continuous-agitation system.

When its use is modified to conform to conditions above noted it should be of distinct value in designing continuous-agitation plants. It also affords a starting point for estimating the relative merits of various continuous-agitation systems and for determining whether continuous agitation is suitable to the reaction under consideration.

TABLE 1

| Computed by formula $V_n = -z^2(1 + z + \frac{1}{2}z^2 + \dots + \frac{1}{n-1}z^{n-1})(z)^{\frac{n-1}{2}}$ |       |       |       |       |       |       |       |       |         |
|------------------------------------------------------------------------------------------------------------|-------|-------|-------|-------|-------|-------|-------|-------|---------|
| Value of $V_n$ from $V_1$ to $V_n^*$                                                                       |       |       |       |       |       |       |       |       |         |
| $B$                                                                                                        | $ZT$  | $V_1$ | $V_2$ | $V_3$ | $V_4$ | $V_5$ | $V_6$ | $V_7$ | $V_7^*$ |
| 200.00                                                                                                     | 0.005 | 0.995 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000   |
| 100.00                                                                                                     | 0.010 | 0.990 | 0.999 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000   |
| 66.67                                                                                                      | 0.015 | 0.985 | 0.998 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000   |
| 50.00                                                                                                      | 0.020 | 0.980 | 0.999 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000   |
| 40.00                                                                                                      | 0.025 | 0.975 | 0.998 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000   |
| 33.33                                                                                                      | 0.030 | 0.971 | 0.999 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000   |
| 30.00                                                                                                      | 0.04  | 0.962 | 0.996 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000   |
| 20.00                                                                                                      | 0.05  | 0.951 | 0.993 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000   |
| 16.67                                                                                                      | 0.06  | 0.942 | 0.998 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000   |
| 14.28                                                                                                      | 0.07  | 0.932 | 0.997 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000   |
| 12.50                                                                                                      | 0.08  | 0.923 | 0.997 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000   |
| 11.11                                                                                                      | 0.09  | 0.914 | 0.996 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000   |
| 10.00                                                                                                      | 0.10  | 0.905 | 0.995 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000   |
| 6.67                                                                                                       | 0.15  | 0.861 | 0.991 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000   |
| 5.00                                                                                                       | 0.20  | 0.819 | 0.983 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000   |
| 4.00                                                                                                       | 0.25  | 0.780 | 0.974 | 0.998 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000   |
| 3.33                                                                                                       | 0.30  | 0.741 | 0.963 | 0.996 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000   |
| 2.50                                                                                                       | 0.40  | 0.670 | 0.938 | 0.990 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000   |
| 2.00                                                                                                       | 0.50  | 0.607 | 0.910 | 0.985 | 0.998 | 1.000 | 1.000 | 1.000 | 1.000   |
| 1.67                                                                                                       | 0.60  | 0.549 | 0.879 | 0.977 | 0.999 | 1.000 | 1.000 | 1.000 | 1.000   |
| 1.43                                                                                                       | 0.70  | 0.497 | 0.844 | 0.961 | 0.989 | 0.999 | 1.000 | 1.000 | 1.000   |
| 1.25                                                                                                       | 0.80  | 0.449 | 0.809 | 0.948 | 0.981 | 0.998 | 1.000 | 1.000 | 1.000   |
| 1.11                                                                                                       | 0.90  | 0.407 | 0.772 | 0.937 | 0.986 | 0.998 | 0.999 | 1.000 | 1.000   |
| 1.00                                                                                                       | 1.00  | 0.368 | 0.736 | 0.920 | 0.980 | 0.996 | 0.998 | 1.000 | 1.000   |
| 0.911                                                                                                      | 1.10  | 0.333 | 0.699 | 0.900 | 0.974 | 0.994 | 0.998 | 1.000 | 1.000   |
| 0.833                                                                                                      | 1.20  | 0.303 | 0.663 | 0.880 | 0.965 | 0.992 | 0.998 | 0.999 | 1.000   |
| 0.769                                                                                                      | 1.30  | 0.273 | 0.627 | 0.857 | 0.957 | 0.989 | 0.998 | 0.999 | 1.000   |
| 0.666                                                                                                      | 1.50  | 0.224 | 0.558 | 0.809 | 0.935 | 0.982 | 0.995 | 0.999 | 1.000   |
| 0.588                                                                                                      | 1.70  | 0.183 | 0.493 | 0.757 | 0.907 | 0.975 | 0.992 | 0.999 | 1.000   |
| 0.500                                                                                                      | 2.00  | 0.145 | 0.416 | 0.687 | 0.876 | 0.967 | 0.974 | 0.982 | 0.995   |
| 0.400                                                                                                      | 2.50  | 0.082 | 0.287 | 0.544 | 0.758 | 0.890 | 0.957 | 0.986 | 0.986   |
| 0.333                                                                                                      | 3.00  | 0.050 | 0.199 | 0.423 | 0.646 | 0.815 | 0.916 | 0.966 | 0.966   |
| 0.285                                                                                                      | 3.50  | 0.030 | 0.166 | 0.336 | 0.532 | 0.704 | 0.833 | 0.933 | 0.933   |
| 0.250                                                                                                      | 4.00  | 0.022 | 0.092 | 0.288 | 0.445 | 0.611 | 0.768 | 0.871 | 0.871   |
| 0.222                                                                                                      | 4.50  | 0.011 | 0.061 | 0.173 | 0.342 | 0.532 | 0.703 | 0.832 | 0.832   |
| 0.200                                                                                                      | 5.00  | 0.007 | 0.040 | 0.124 | 0.265 | 0.410 | 0.616 | 0.762 | 0.762   |
| 0.167                                                                                                      | 6.00  | 0.004 | 0.025 | 0.078 | 0.151 | 0.285 | 0.478 | 0.655 | 0.65    |

## DERIVATION OF FORMULA BY ANDREW HAM

For general explanation see Part I of this article.

Let  $a_j =$  a small quantity of material entering the system during a negligible interval of time.

Let  $t$  = time, rated from the entrance of  $a_0$  into the system.

Let  $R$  = rate of flow of material into the system and from tank to tank.

Let  $c$  = capacity (volume) of each tank in the system.  
 Let  $a$  = the quantity of  $a_0$  remaining in tank No. 1  
 after time  $t$ .

Then  $\frac{a}{c}$  = quantity of  $a$ , in a unit volume of the contents of number 7 tank at any time.

—  $R_c^a$  = the rate at which  $a_o$  is leaving tank No. 1.



+  $\frac{da}{dt}$  = the rate at which  $a_o$  is leaving tank No. 1.

$$\therefore \frac{da}{dt} = -\frac{Ra}{c} \text{ or } \frac{1}{a} da = -\frac{R}{c} dt.$$

Let  $\frac{R}{c} = z$  (a constant for the problem considered)

$$\text{Then } \frac{1}{a} da = -z dt, \quad \int \frac{1}{a} da = \int -z dt$$

$$\log a = -zt + c \quad (c = \text{constant of integration})$$

$$a = e^{-zt+c} = (e^{-zt})(e^c)$$

Let  $t = 0$ ; then  $a = a_o$  and  $a_o = (1)(e^c)$

$\therefore a = a_o e^{-zt}$  or  $\frac{a}{a_o} = e^{-zt}$  (I). This is the fraction of  $a_o$  in tank No. 1 after any time  $T$ . Call this fraction  $v_1$ .

#### CONSIDERATION OF TANK No. 2

$\frac{da}{dt}$  = rate at which  $a_o$  leaves tank No. 1 at time  $t$ .

$$da = -a_o z e^{-zt} dt \quad (\text{from (I)}).$$

$-da$  = the quantity of  $a_o$  entering tank No. 2 during interval  $dt$  at time  $t$ .

$\frac{da}{-da}$  = the fraction of  $(-da)$  remaining in tank No. 2 after time  $t$ , rated from the entrance of  $(-da)$  at time  $t$ .

Hence, by comparison with (I):

$$\frac{da'}{(-da)} e^{-zt} = (a_o z e^{-zt} dt) e^{-zt}.$$

Let  $t + t_1 = T$ , a constant, the time for which the investigation is being made. Then  $t_1 = T - t$  and  $da' = a_o z e^{-zt} dt$ .

$a' = \int a_o z e^{-zt} dt = a_o z t e^{-zT} + c'$  ( $c' = 0$  = constant of integration).

$\therefore$  at time  $T$ ,  $a' = a_o z t e^{-zT}$  or  $\frac{a'}{a_o} = z T e^{-zT}$  (II). This is the fraction of  $a_o$  remaining in tank No. 2 after time  $T$  rated from the entrance of  $a_o$  into system. Call this fraction,  $v_2$ .

#### CONSIDERATION OF TANK No. 3

Here we have the condition of a continuous supply of  $a_o$  reaching tank No. 2 and also leaving it, whereas in No. 1  $a_o$  arrived all at once.

$-da$  enters No. 2 in interval  $dt$  and  $\frac{da'}{dt}$  (the rate of change in the quantity of  $a_o$  in No. 2 is made up of  $(\frac{da}{dt})$  and the rate of  $a_o$  passing to tank No. 3.

$$\text{Hence } \frac{da'}{dt} + \frac{(-da)}{dt} = (a_o z^2 t e^{-zt} - a_o z e^{-zt})$$

$= a_o z^2 t e^{-zt}$  is the rate at which  $a_o$  is entering No. 3 at time  $t$ .

$-(da' + da) = a_o z^2 t e^{-zt} dt$  = quantity of  $a_o$  entering No. 3 during  $dt$  at time  $t$ .

$\frac{da''}{-(da' + da)}$  = fraction of  $-(da' + da)$  remaining in No. 3 at time  $t$ , rated from entrance of  $-(da' + da)$ .

By comparison with (I):

$$\frac{da''}{-(da' + da)} e^{-zt_1} = (a_o z^2 t e^{-zt} dt) e^{-zt_1}.$$

Again let  $T = t + t_1$ ; then

$$da'' = a_o z^2 t e^{-zt} dt.$$

$$\int da'' = a'' = \int_{t=0}^{t=T} a_o z^2 t e^{-zt} dt = a_o \frac{z^2 T^2}{2} e^{-zT}.$$

$$\frac{a''}{a_o} = \frac{z^2 T^2}{2} e^{-zT}. \quad (\text{III}). \text{ This is the fraction of } a_o$$

remaining in Tank No. 3 after time  $T$  rated from the entrance of  $a_o$  into the system. From the above we have  $v_1 = e^{-zt}$ ,  $v_2 = e^{-zt} zt$ ,  $v_3 = e^{-zt} \frac{z^2 t^2}{2}$ . The general expression for  $v_n$  ( $n$  being greater than 1) is

$$v_n = e^{-zt} \frac{(zt)^{n-1}}{1.2.3 \dots (n-1)}.$$

If we let  $V_1, V_2, V_3 \dots V_n$  be the total fraction of  $a_o$  remaining in the first tank; first two tanks, first three tanks, ... first  $n$  tanks, then

$$V_n = e^{-zt} \left( 1 + zt + \frac{z^2 T^2}{2} + \dots + \frac{(zt)^{n-1}}{1.2.3 \dots (n-1)} \right).$$

This is the general formula for the fraction of  $a_o$  remaining in a system of  $n$  tanks after time  $T$ , rated from the entrance of  $a_o$  into the system.

#### Importation of Optical Glass Controlled by the Government

The importation into the United States of French optical glass is to be controlled by the Government. American manufacturers and importers desiring this glass must place their orders through the War Industries Board and the War Trade Board. Direct orders will lack the government approval and necessary endorsements to allow the importation.

Regulations for the importation of French optical glass adopted following conferences between the Military Optical Glass and Instruments Section of the War Industries Board, of which George E. Chatillon is chief, and the Bureau of Imports of the War Trade Board, provide:

1. All import orders for French optical glass should be placed with the Service Geographique, who will distribute them among the various French manufacturers.
2. The order, together with the application for import licenses, should be forwarded to the War Trade Board, Bureau of Imports, to the attention of Mr. Rearson.
3. The applications should state in detail the purpose for which the glass is intended.
4. The War Trade Board will in all cases consult with the Military Optical Glass Section of the War Industries Board before applications are granted.
5. Orders placed direct will not have the approval of the Military Optical Glass Section nor the necessary endorsement of the War Trade Board to allow the glass to be imported from France.
6. If glass of a special manufacturer is desired, it may be noted on the order.

#### Production of Hand Grenades

Major General C. C. Williams, chief of ordnance, has written the Single Service Package Corporation of New York City, commending the employees of that plant for having attained a production speed of more than 100 hand grenades a minute.

The third million of grenades made by this concern was shipped to France the middle of last month, having been produced in exactly one month's time. During the week ending September 14, the plant shipped a total of more than 300,000, or 55,000 a day, Saturday being counted as four-ninths of a day, and this despite the fact that the plant was closed down ahead of time September 12 to permit employees to register under the Selective Service draft act. The maximum production was attained Friday, September 13, when 55,200 grenades were turned out. Simple as a completed grenade seems, it requires twenty-five distinct operations.

# Commercial Uses of Chlorine\*

A Review of the Direct and Indirect Applications of Chlorine in Independent Uses, Metallurgy, Poisonous Gases, Inorganic Salts and Organic Solvents, Pharmaceuticals and Intermediates

By V. R. KOKATNUR

THE electrolytic manufacture of caustic soda during the last decade or so has brought such new problems to the fore, which if not solved immediately seem to threaten the very life of the industry that has given them birth. The electrolysis of brine produces caustic soda, hydrogen and chlorine. Caustic soda produced by the Solvay Process is decidedly cheaper than electrolytic caustic, while electrolytic chlorine can be made cheaper than chlorine made by other methods.

Thus it is easy to see that the success of the electrolytic alkali industry depends not so much upon the profits obtained from caustic as upon those from chlorine. Though the main object in the electrolysis of brine is caustic soda, chlorine thus assumes a greater importance in the electrolytic alkali industry. In other words, the evaluation of the products of electrolysis of brine depends not so much on our motive of electrolysis as on the practical side of the question. Hence chlorine becomes important as a primary-product, since among the products of electrolysis, it is at the same time the most important and the cheapest.

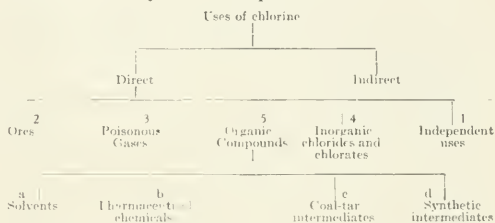
After all, the question whether a product should be called a primary-product or a by-product is settled by its cheapness of manufacture and its utility, and from this standpoint chlorine can be called a primary-product and not a by-product. While hydrogen can be thrown away without much detriment to the neighboring community, chlorine cannot be so dealt with, even if it was so desired, on account of the damage suits such a step might involve. In addition we cannot afford to throw it away since electrolytic caustic cannot successfully compete with Solvay caustic unless its allies, hydrogen and especially chlorine, reinforce and strengthen its ranks.

We are thus confronted with the double necessity of utilizing chlorine, first because we cannot afford to throw it away, and secondly because we cannot throw it away, even if we wanted to, without serious trouble. The unprecedented stimulus given to the chemical industry as a whole by the present war, and its certain growth after the war, will undoubtedly expand the electrolytic alkali industry far beyond its present confines.

Such a growth will result in an enormous production of chlorine. The present consumption of chlorine in the production of bleaching powder or hydrochloric acid cannot further be extended without seriously overflowing the world's markets. Besides it is not profitable. Thus we are confronted with a problem most vital to the life of the alkali industry—a problem which is fraught with grave consequences and pregnant with possibilities; a problem of finding new and profitable

uses of chlorine—and if this problem is not solved, it will mean slow but sure death to the industry.

This paper does not claim any originality in its contents. Its main object is to present a systematic treatment of the possible ways of utilizing chlorine, showing the avenues and by-paths. Some of these by-paths show signs of considerable traffic, while others are hardly used and show but few footprints. The known roads are the ones that are followed by many as they offer the least resistance. None but the daring explore the new roads lest they lead them astray to be lost in the wilderness. As in everything else, it is the new road that opens up fields of profitable endeavor and the chlorine industry is no exception.



This table shows the classification of the different ways of possibly utilizing chlorine. Some of these look like footpaths and have a small and limited application, while others appear like beautiful and broad avenues, on which one can travel far and wide, nay, can even cross the continent.

## DIRECT USES

### 1. INDEPENDENT USES

Among these may be mentioned its use as a bleaching agent in water solution in the textile and paper industries.

It finds use as a disinfectant and sterilizer of potable water, whereby typhoid, cholera and other epidemic diseases are completely eliminated from cities wherever it has been used.

Recently it has been used in the treatment of wounds and their asepsis through what is known as Dakin-Carrel solution.

Liquid chlorine is known to have been used in gas-warfare in producing smoke-screens or clouds.

It can be used in fumigating houses, thus destroying the microbes of plague and other diseases.

It is used in sewage treatment and also in sterilizing raw-hides.

### 2. CHLORINATION OF ORES

There have been many patents on the chlorination of ores for specific purposes in metallurgy. Here seems

\*Read before the American Electro-chemical Society at Atlantic City, N. J., Oct 1, 1918.

to be a vast field, as a large tonnage of chlorine will be consumed, if in any such line it may find application.

It has been used for the separation of gold or silver from base metals and thus finds an indirect application in the metallurgy of gold and silver.

It is also used in separating copper from nickel, *i. e.*, in the metallurgy of both copper and nickel.

It is used in separating tin as tin-tetra-chloride from tinned iron-scrap by what is known as Goldschmidt's Detinning Process.

It finds application in the extraction of valueless ore-residues, which could not be profitably worked out except by the use of chlorine. Thus a low percent-ore can be worked out successfully to advantage by its use and its valuable metal contents be made available for our use.

The chlorination of ores can be extended *ad infinitum* to newer fields of adventure, taking advantage of the volatility of certain chlorides and the action of chlorine on different metals and metallic oxides. Thus perhaps iron-pyrites may be used for iron manufacture and feldspars may some day give us our potash and aluminium.

### 3. POISONOUS GASES

Gas warfare is perhaps the most unforeseen development of the present war and opens up interesting fields. It is interesting to note that more than fifty per cent of the gases known to be used in the present war are chlorine compounds.

Silicon-tetra-chloride ( $\text{SiCl}_4$ ) and titanium-tetra-chloride ( $\text{TiCl}_4$ ) are used in producing smoke-screens. Chloro-sulphonic acid ( $\text{SO}_2\text{HCl}$ ) used in hand-grenades and smokepots. Phosgene ( $\text{COCl}_2$ ) is used in shells as an offensive gas. Chloroacetone ( $\text{CH}_3\text{ClCOCH}_3$ ) and trichloro-methyl-chloro-formate ( $\text{Cl-COOCCl}_2$ ) known as superpalate are used in shells as lachrymators. Benzyl-chloride ( $\text{C}_6\text{H}_5\text{-CH}_2\text{Cl}$ ) is used as a tear-gas in shells; chloropicrin or nitrochloroform ( $\text{C}(\text{NO}_2)_3\text{Cl}$ ) also as a tear-gas in shells, mustard gas, *i. e.* dichlorodiethyl-sulphide ( $(\text{C}_2\text{H}_5\text{Cl})_2\text{S}$ ), in shells for both offensive and neutralization, diphenylchlorarsene ( $(\text{C}_6\text{H}_5)_2\text{AsCl}$ ) in shells as a "sneezing gas"; phenyl-carballymine-chloride ( $\text{C}_6\text{H}_5\text{NCCl}$ ) in shells as a lachrymator; dichloromethyl-ether ( $(\text{CH}_3\text{Cl})_2\text{O}$ ) in shells and methyl-chloro-sulphonate ( $\text{CH}_3\text{ClSO}_3$ ) in hand-grenades.

Other so-called gases are benzyl-bromide ( $\text{C}_6\text{H}_5\text{CH}_2\text{Br}$ ) used in shells, bromoacetone ( $\text{CH}_3\text{BrCOCH}_3$ ) in hand grenades, bromo and dibromoketones like ( $\text{CH}_3\text{BrCOC}_2\text{H}_5$ ), ( $\text{CH}_3\text{COCHBrCH}_2\text{Br}$ ) in shells; xylbromide ( $\text{CH}_3\text{CH}_2\text{CH}_2\text{Br}$ ) in shells; allylthio-cyanate ( $\text{C}_3\text{H}_5\text{-NCS}$ ) in shells; dimethylsulphate ( $(\text{CH}_3)_2\text{SO}_4$ ) in hand grenades, and sulphur-tri-oxide, ( $\text{SO}_2$ ) in hand grenades and shells. It has recently been found that cyanogenchloride ( $\text{CNCl}$ ) and butyl-mercaptan ( $\text{C}_4\text{H}_9\text{-SH}$ ) are also used.

It will be noticed here that many of these non-chlorine gases are capable of being produced from chloro-compounds, *i. e.*, using chlorine in intermediate steps. For example, allylthiocyanate can be prepared from allylchloride and potassium sulphocyanate ( $\text{KCNS}$ ); methylsulphate from methyl-alcohol and sulphuryl-chloride; benzyl-bromide from benzyl-chloride and potassium bromide ( $\text{KBr}$ ). Hence it would not be far from truth to say that more than 95 per cent of the

poisonous gases can be made directly or indirectly by the use of chlorine.

It is to be regretted that these gases should have been used for incapacitating or destroying human beings, when if intelligently directed they might well serve a useful purpose. There is no reason why they could not be made to save us and our crops from the ravages of microbes and insects, as they are saving us today from the ravages of Prussian militarism. We must not forget that our worst enemies turn out to be our best friends when properly controlled and directed just as some of the worst poisons, like strychnine and morphine, have proven to be.

### 4. INORGANIC CHLORINE COMPOUNDS

There are many metallic and non-metallic chlorides that have found an extensive application in arts and industries. Chloride of lime or bleaching powder, as it is sometimes called, is used extensively in bleaching, as its name indicates. It is used also in purifying water, as a disinfectant, and in many cases as an oxidizing agent. It is also used advantageously in chlorination of basic substances, like amines, to produce chloramines, and often gives quite different results from ordinary chlorination.

Sulphur-mono-chloride ( $\text{S}_2\text{Cl}_2$ ) is used extensively in vulcanizing rubber, making rubber substitutes from oils and fats and preparing the surface of thousands of useful articles. It is also used in defatting cane-juice (sugar refining). It can be advantageously used in the preparation of chlorides free from oxychlorides. It may also find application in preparing organic sulphides.

Sulphuryl-chloride ( $\text{SO}_2\text{Cl}_2$ ) and thionyl-chloride ( $\text{SOCl}_2$ ) can be used in the preparation of acid chlorides from acid salts and as chlorinating agents. Sulphuryl-chloride can be used in the manufacture from sodium acetate of acetic anhydride, an invaluable ingredient in the manufacture of dyes, cellulose acetate and many other drugs.  $4\text{CH}_3\text{-COONa} + 2\text{SO}_2\text{Cl}_2 = 2(\text{CH}_3\text{CO})_2\text{O} + 2\text{NaCl} + \text{Na}_2\text{SO}_4$ .

Phosphorus chlorides such as phosphorous trichloride ( $\text{PCl}_3$ ), phosphorous pentachloride ( $\text{PCl}_5$ ), and phosphoryl or phosphorous oxychloride ( $\text{POCl}_3$ ) are all used as chlorinating agents, particularly valuable for the substitution of hydroxyl or oxygen by chlorine. Thus they can be used to prepare ethyl-chloride from alcohol or ether and acid-chlorides from fatty acids.

Antimonytrichloride or butter of antimony ( $\text{SbCl}_3$ ) is used as a caustic in medicine, in the preparation of tartar-emetic and as a "bronzing" solution for gun barrels and other instruments. Antimony-pentachloride is often used as a chlorinating agent to serve the purpose of phosphorous chlorides.

Anhydrous aluminium chloride is used extensively in organic synthesis and recently has found application in the "cracking" of petroleum oils to obtain gasoline. Ferric-chloride can be used for similar purposes.

Tin-tetra-chloride ( $\text{SnCl}_4$ ) is used in cotton-printing and silk dyeing, while stannous chloride ( $\text{SnCl}_2$ ) has an extensive use as a reducing agent. Zinc chloride is used for the impregnation of telegraph poles and railway ties to prevent rot, and also in vulcanizing fiber goods. Zinc oxychloride is used as a cement in dentistry.

Mercuric chloride ( $\text{HgCl}_2$ ) and calomel ( $\text{Hg}_2\text{Cl}_2$ ) are both used as antiseptics and in medicine. Silver-chlo-



ride in its colloidal form is used extensively in photography. Other chlorides have not yet found industrial application.

Sodiumhypochloride is used extensively in solution for bleaching and as an antiseptic, but if solid sodiumhypochloride could be produced it would be extremely valuable. So far no attempt seems to have been made in this direction, but the day is not far distant when it will be manufactured in large quantities.

Different chlorates like those of sodium, potassium, calcium and barium are used in the manufacture of matches, cartridges, fireworks, dyes and as lozenges for sore throat.

Perchlorates also are being used more and more. Ammoniumperchlorate is perhaps the most economic and at the same time the most terrific of explosives. It is destined to play, in the near future, an important part in industries like mining, especially as there is a great shortage of animal fats, glycerin from which goes to make our dynamites. It is surprising that our government should not have taken any steps in this direction.

##### 5. ORGANIC COMPOUNDS

Chlorine finds an extensive use in various organic compounds as tabulated below under various sub-headings.

*c. Coal-tar intermediates:* Among the most important coal-tar intermediates may be mentioned a derivative of benzene called chlor-benzene, or, as it is sometimes wrongly called, chlor-benzol. It finds an extensive use in the dye industry and in the manufacture of picric acid. Dichlorobenzenes have not so far found any industrial application. It is needless to say that the still higher chlorobenzenes are worse off in this respect. It seems that mono-chlor-benzenes may find application as a solvent, as it can be manufactured cheaply and as it is a more stable compound than aliphatic chlorides, which generally decompose in the presence of moisture and light.

Chlor-toluenes like benzyl-chloride ( $C_6H_5CH_2Cl$ ) can be used to make benzyl-alcohol, which has a good demand in the essential oil industry. Benzol-chloride ( $C_6H_5CHCl_2$ ) is used to manufacture synthetic oil of bitter almonds or benzaldehyde, which is also used in vast quantities in the perfume industry. Benzotrichloride or phenylchloroform ( $C_6H_5 \cdot CCl_3$ ) is used to manufacture benzoic acid. Chlorobenzoic and salicylic acids have a limited application.

Chlorphenols and cresols are used in synthetic work. Recently some chlor-naphthalenes have been used as solvents and in making waxy condensation products for insulation purposes. Chlor-naphthalenes may open up new fields for the dyes of naphthalene series. Chloranilines have a limited application in the dye industry, while chloranil or tetrachlorobenzoquinone has a great demand. The chlorination of anthracene may also open up new fields in the dye industry.

Chlor-acetic acids also are extensively used in dye manufacturing. Monochlor-acetic acid plays an important part in the synthesis of indigo. Dichloroacetic acid is used in the synthesis of isatin. Trichloroacetic acid is used extensively in medicine.

Phosgene ( $COCl_2$ ) is used in triphenylmethane dyes and in the synthesis of acids and ketones, especially Michaeler's Ketone.

*b. Pharmaceutical chemicals:* Very little attempt has been made to bring chlorine compounds of pharmaceutical value on the market. In this line chloroform must be mentioned as one being extensively used as an anesthetic. It is also used as an antiseptic and is even used internally in medicine. It is also used in dentistry.

Chloral ( $CCl_3CHO$ ) finds application as a hypnotic or soporific. Both chloral and chloroform are at present very expensive and a cheaper method of manufacture would be a boon to humanity.

Methylene-chloride finds some use as a local anesthetic. Ethyl-chloride is used also as a local anesthetic, and in conjunction with others in some form as a hypnotic. Isopral or trichlorisopropylalcohol ( $CCl_3CHOH \cdot CH_3$ ), chloramide or chloralformamide ( $CCl_3CHOH \cdot NH \cdot CHO$ ), chloralimide ( $CCl_3CHNH$ ) and dormiol ( $CCl_3CH(OH)O \cdot C_2H_5$ ) are used in various ways in pharmacy. Ethylene-chloride ( $C_2H_4Cl_2$ ), or "Dutch Liquid," is used as an inhalant and local anesthetic.

Chloretone or acetone-chloroform ( $CCl_3(CH_3)_2COH$ ) is used as a local anesthetic in conjunction with cocaine and adrenaline. Chlor-phenols and cresols are antiseptics of great value, being several times stronger than phenols and cresols and yet are free from their toxic effects. Some chlorinated oils have been tried in Europe for their medicinal value.

Many chlorine compounds like hexachlor-ethane and hexachlor-benzene are likely to be useful either as antiseptics or vermicides, or in both. They may find extensive application in the washing and sterilization of milk cans, as chlorine-solvents are good fat-extractors and antiseptics at the same time.

Dichloramine-T or p-toluene-sulphon-chloramide has been recently used by Drs. Dakin and Carrel in the asepsis of wounds. It is a non-irritating, synthetic germicide and corresponds to the antiseptic chloramine substances that are formed when hypochlorous chlorine is brought in contact with the exudate of suppurating wounds. It can be used in doses twenty to forty times stronger than in hypochlorite solution. It has absolutely no destructive effect on tissue-cells like tincture iodine. It is used also as a nasal antiseptic. It has been found to be better than bleaching powder for the purification of water, because of its stability in solution, non-toxicity, absence of corrosive action and non-production of unpleasant taste.

*a. Solvents:* The most extensively used chloro-solvent is carbon-tetra-chloride ( $CCl_4$ ), a compound which is made by the action of chlorine or sulphur-mono-chloride on carbon bisulphide ( $CS_2$ ). It is used as a solvent in the rubber industry and for the extraction of fats. It is also used in dry-cleaning and in fire-extinguishing mixtures like "Pyrene."

Chloroform ( $CHCl_3$ ) is used to a limited extent as a solvent in electrotechnics in the rubber-industry and in photography. Methylene-chloride, though a good solvent, has not been widely used.

Ethylene-chloride or "Dutch Liquid" ( $C_2H_4Cl_2$ ) is a solvent of great value. It resembles carbon-tetrachloride in most respects and is a good solvent for cellulose acetate. It can be made cheaply by chlorinating ethylene gas obtained by either "cracking" oil gas or by limited hydrogenation of acetylene. Besides being a solvent of great value, it is very useful in the synthesis



*d. Synthetic intermediates:* There are many organic chlorine compounds, which though incapable of being used as such in arts and industries, are nevertheless very useful as intermediate products in the manufacture of other commercial products. Most chloro-hydrocarbons can be used to make unsaturated hydrocarbons of value. Organo-metallic compounds like zinc methyl ( $\text{Zn}(\text{CH}_3)_2$ ) and magnesium-methyl-chloride are useful for preparing synthetic hydrocarbons, secondary and tertiary alcohols and fatty acids.

Trichloropropane or trichlorohydrin ( $\text{CH}_2\text{ClCHClCH}_2\text{Cl}$  B.P.  $158^\circ$ ) though in itself not very useful, forms the basis of the synthesis of glycerol, a product of immense value in arts. Amylchloride and dichloropentane are useful in the synthesis of amylalcohol, amylacetate and isoprene.

$\text{H}_3\text{C} \searrow \quad \text{C} = \text{C} \quad \text{CH}_2$   
 $\text{H}_3\text{C} \nearrow \quad \quad \quad \text{H}$  Both amylalcohol and amylacetate are used extensively in the celluloid industry, while isoprene forms the parent substance of rubber, a substance which has entered into many phases of human needs.

Chloro-acetons can be used for the synthesis of citric acid or of glycerol. Monochloralkyls or chlorohydrocarbons can be used to build up higher hydrocarbons or for the introduction of alkyl groups in other organic compounds. Various acid chlorides like acetyl chloride or benzoyl chloride are used to make acid anhydrides or for the introduction of acetyl or benzoyl radicals.

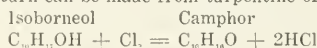
The chlorine compounds are so vital in organic chemistry that but for their help directly or indirectly very few organic compounds could be prepared. Neither the amino group  $\text{NH}_2$ , nor the sulphonic group  $\text{HSO}_3$ , neither the sulphite radical  $\text{SO}_2$  nor the hydroxyl acid radical  $\text{OH}$ , neither the nitro group  $\text{NO}_2$  nor the nitrite radical  $\text{NO}$ , neither the acetyl radical  $\text{CH}_3\text{CO}$  nor the carboxyl group  $\text{COOH}$ , neither the alkyl nor the alkoxy group, can be substituted without their help. In fact, if any process is more useful, far-reaching and universal in application in organic chemistry it is chlorination. The halogens are the most intimate friends of the hydrocarbons and without their consent and coöperation no work of any kind is undertaken by hydrocarbons themselves.

If I may here be permitted to mention a personal experience in teaching, I would like to relate my experience in explaining the behavior of various hydrocarbons in organic chemistry.

To remove the confusion regarding the behavior of saturated and unsaturated hydrocarbons, I compared the saturated hydrocarbons to wealthy and completely self-satisfied people, while I called the unsaturated hydrocarbons needy beggars. Now beggars accept gifts but do not give anything in return. Saturated hydrocarbons on the other hand being "rich" are always ready, if they need anything, to give something in return. But the trouble is that they already have everything and need nothing. Hence they are the hardest to be induced to do anything. The only way to make them act as you desire is to approach them, not directly, but through their most intimate friends, the halogens, just as you have to have a "pull" to get a politician to do you a favor. If you can reach them through a friend they will do anything for you.

Among the indirect uses of chlorine can be mentioned its value as an oxidizing agent. Thus it can be used

to make potassiumpermanganate from potassium manganate,  $2\text{K}_2\text{MnO}_4 + \text{Cl}_2 = 2\text{KMnO}_4 + 2\text{KCl}$ . It can be used in the manufacture of potassium ferri-cyanide from potassium ferro-cyanide.  $2\text{K}_4\text{Fe}(\text{CN})_6 + \text{Cl}_2 = 2\text{K}_3\text{Fe}(\text{CN})_6 + 2\text{KCl}$ . A similar application can be found in making lead peroxide from litharge or lead acetate (sugar of lead);  $\text{PbO} + \text{MgO} + \text{Cl}_2 = \text{PbO}_2 + \text{MgCl}_2$  or  $\text{Pb}(\text{OOCCH}_3)_2 + 2\text{HCl} = \text{PbO}_2 + 2\text{CH}_3\text{COOH} + \text{Cl}_2$ . Similarly superphosphate can be made from phosphate.  $\text{Ca}_3(\text{PO}_4)_2 + 2\text{SO}_2\text{Cl}_2 + 4\text{H}_2\text{O} = 2\text{CaSO}_4 + \text{Ca}(\text{H}_2\text{PO}_4)_2 + 4\text{HCl}$ . It can be used in making artificial camphor from Isoborneol, which in turn can be made from turpentine or pinene.



By its use pure cellulose can be obtained from wood-pulp.

Dr. Wintlein mentions an experiment whereby 100 parts, by weight, of dried pine-wood, treated by lime and chlorine, gave 50 parts, by weight, of pure cellulose. Bleaching powder can be used to produce pure oxygen gas from what is technically known as lavosite.

Thus it can be seen that chlorine has an extensively wide application in both inorganic and organic industries and supplies many human wants. It bleaches our linen, purifies our water, protects us from epidemic diseases and helps us in making dentistry and surgery painless. It is our companion in homes, companion in camp, companion in peace and companion in war.

The end of this war will find an enormous excess of chlorine in this country and the problem of turning this vast otherwise nuisance material into useful channels will be before us. The electrolytic alkali manufacturers of this country will do well to think and not wait until they are face to face with it. We must remember that a stitch in time saves nine. A little foresight and forethought will go a long way in helping to solve this problem.

Some manufacturers think that if they seek today new applications for their by-products they would be trespassing on the field of their present customers who are buying chlorine. But it should be remembered that a customer buys chlorine only when he can make money for himself. He makes only such chlorine products as are in demand at a good price. He is not interested in buying chlorine to find new uses for it. Consequently he is not the man to experiment. As a matter of fact it is the manufacturer who lives or dies and who is the one most concerned. It is up to him to sound the depth of this unexplored region.

Research Department,  
 Niagara Alkali Co.,  
 Niagara Falls, N. Y.

### Basic Exchange in Permutite

Rothmund and Kornfeld in *Zeitschrift anorg. Chemie* 103, pp. 129-163, state that the basic exchange which takes place between hydrated aluminosilicates, such as the soil zeolites or the artificial product permutite, and neutral salt solutions is a true chemical substitution of an alkali metal for an earth and not a process of adsorption. In the case of permutite, equilibrium is rapidly established between the solid and a neutral salt solution, and the composition of the resulting permutite is found to depend upon the relative concentrations of the interchangeable bases in solution.



## The Development of the Ferro-Manganese Industry in the United States Since 1914\*

By THEODORE SWANN

PRIOR to 1914 the United States produced less than one-half of its ferro-manganese requirements, and in 1914 only 54% out of a total 183,728 tons of ferro-manganese produced and imported. In 1917 the total production and imports increased to 331,381 tons, of which 286,000 tons, or 86%, was produced in the United States, and in 1918 the percentage of home production will not be less than 90%.

### SOURCES OF MANGANESE SUPPLIES

It is well known that under pre-war conditions the world's supply of manganese ore came mainly from Brazil, India and Russia. Thus the shortage of shipping brought about by the war made it necessary that the United States develop to the greatest extent possible its own manganese ore resources.

The production of manganese ore in the United States in 1914 was 2635 tons; this was insufficient to make one-half of one per cent of the ferro-manganese required.

In 1915, domestic production of manganese ore increased to 9709 tons, or enough to make about two per cent of our requirements. During 1916 the domestic production increased more than treble that of the previous year, we producing 26,997 tons of manganese ore, or enough to make less than three per cent of our increased ferro-manganese requirements. In 1917 the production of high-grade domestic ore quadrupled that of the previous year's output. We produced 113,734 tons of high-grade manganese ore, or enough to make over 10% of the ferro-manganese required.

The domestic ore production of 1917 only supplemented the foreign ores, the shipment of which was rapidly becoming more difficult. During the first six months of the present year 1918, we find the high-grade domestic manganese ore production greater than that of the entire year of 1917, with prospects for decided increase in the second half over that of the first half.

### PRODUCTION OF FERRO-MANGANESE

During July, 1918, a total of 30,370 tons of ferro-manganese was produced containing 20,226 tons of metallic manganese; 23,021 tons of spiegeleisen was produced containing 4698 tons of metallic manganese, making a total of 24,924 tons of metallic manganese in the total ferro-manganese and spiegeleisen produced. The percentage of metallic manganese derived from domestic ores in the above tonnage for July 1918 was 47.9 per cent.

It has been estimated from the consumption to date this year that the iron and steel industry will require during the remainder of this year and the first half of 1919, 31,000 tons per month of metallic manganese in the form of ferro-manganese and assuming that the average grade will be 65%, the monthly requirements of ferro-manganese will be 32,300 tons; in addition 3000 tons per month of metallic manganese in the form of

spiegeleisen will be required; assuming the average grade to be 18% the monthly requirements will be 16,500 tons.

The total metallic manganese requirements for the year ending June, 1919, for both ferro-manganese and spiegeleisen are therefore assumed to be 288,000 tons; from the best information available at this time the United States will produce ores that will contain at least 50% of the manganese content required to make this tonnage of ferro-manganese and spiegeleisen.

At the May meeting of the American Iron and Steel Institute, Mr. C. R. Ellicott presented a most complete and instructive paper, entitled, "The Conservation of Manganese." In addition to the facts so ably presented by Mr. Ellicott, we desire to pay tribute to the many producers of domestic manganese ore who by their efforts are rapidly making the United States less dependent upon other countries for our supply of manganese ores. We strongly urge that it is the patriotic duty of both the producers and users of manganese alloys to encourage in all ways possible the production of domestic ores and to further break away from the old prejudice against the use of lower grade alloys.

### ADVANTAGES OF SILICO-MANGANESE ALLOYS

It has been suggested that the steel industry could further aid in the conservation of shipping by using, when possible (in many instances to their direct advantage), silico-manganese which could be made from high silica domestic ores. Some of our prominent metallurgists consider the advantages of silicon alloyed with manganese to be:

First: The silicon forces down the carbon, giving the desired low carbon alloy for the steel addition.

Second: As a dioxidizer the combined selective action of silicon and manganese will be more active as a dioxidizer than either element alone.

Third: The resultant combined oxides forming manganese silicate will, due to its greater fluidity, be eliminated from the metal more readily than the oxides of either alone.

There are numerous deposits of manganese ore too high in silica to be used in making ferro-manganese. These however, are available for making silico-manganese.

### MANGANESE SLAGS

It is possible to make silico-manganese from high slags carrying from 10% and up of manganese and also from manganese ores carrying as low as 18% manganese and as high as 40% silica. While it is not so attractive commercially to use slags and very long manganese ores, this source of supply has been proven to be available by one electric furnace producer. This producer made from slags, running 10 to 17% manganese, several carloads of silico-manganese analyzing about 64% manganese, 12% iron, 23% silicon, and 0.60% carbon. It may be of interest to note that the average slags produced with the above metal run under 4% in manganese.

The manufacture of ferro-manganese in the electric furnace is one of the important developments in connection with the utilization of domestic manganese ores, especially where the plants are located near the ore mines. Not only are such plants conserving ocean transportation, but railway transportation as well.

\*Abstract of paper presented at the Fourth National Exposition of Chemical Industries, Sept. 27, 1918.]

Perhaps the greatest value today of the electric furnace producing ferro-manganese, is the conservation of coke. The majority of electric furnaces are operated and heated by hydro-electric power instead of coke as in the blast furnace.

In July, 1918, over 7½% of the entire production of ferro-manganese was made in the electric furnaces. It is estimated that by the end of this year electric furnaces will be producing about 15% of the total ferro-manganese produced in the United States.

The slag and volatilization losses in the smelting of the ferro-manganese is an ample field for the conservation of our manganese supply. The fundamental causes underlying such losses are problems to be further worked out by our metallurgists. It is believed that it is possible so to improve the past general average practice as to increase the recovery by 10%. If such increase could be made, it would save about 30,000 tons of metallic manganese and thus release over 75,000 tons of shipping.

## Increased Production of Artificial Abrasives

A MARKED increase in the output of artificial abrasives in the first half of 1918, as compared with the first half of 1917, is shown by figures compiled by Frank J. Katz, of the United States Geological Survey, Department of the Interior, and obtained in coöperation with the Mines Branch of the Canada Department of Mines. There was little change in the output of corundum and a decrease in the output of emery.

### EMERY AND CORUNDUM

During the first half of 1918 emery ore was produced by seven operators in the Peekskill district, in New York, and by one in southern Virginia. Corundum is produced from one mine in Macon County, N. C., and by one company operating in Renfrew County, Ontario. The combined mine output of emery and corundum in the United States and Canada from January 1 to June 30, 1918, was 5455 short tons. During the same period the producers sold, shipped, or used in the manufacture of abrasive articles approximately 4500 short tons, and the stock on hand at the mines June 30 was about 1500 short tons. As compared with the same period in 1917, there was a large decrease in the quantity of emery mined, and the output from January to June, 1918, inclusive, was considerably less than half of the mine output of emery for the entire year 1917. During the first half of 1918 corundum was produced at about the same rate as in 1917.

### ARTIFICIAL ABRASIVES

Artificial carbide abrasives, including carborundum, crystolon and carbolon, were produced during the first half of the year 1918 by two companies in the United States, operating plants at Niagara Falls, N. Y., and at Blasdell, N. Y., and by three in Canada, operating plants at Shawinigan Falls, Quebec, and at Chippewa and Thorold, Ontario. The plant output of crude carbide abrasives was 6583 short tons. During the same period the producers sold or used in the manufacture of abrasive materials 5633 tons, and on June 30 there remained in their hands as stocks 2840 tons.

Aluminium oxide abrasives, including alundum, aloxite, exelon, lionite and natite, were manufactured in the United States by four companies, three of which operated plants at Niagara Falls, N. Y., and one at Blasdell, N. Y., and in Canada by five companies, which operated plants at Niagara Falls, Chippewa and Thorold, and two at Hamilton, Ontario. The combined output of these plants in the first half of 1918 was 28,341 short tons. During the same period the producers sold or used in the manufacture of abrasive materials 23,161 short tons, and on June 30 there remained in their hands 26,221 short tons. The combined figures for carbide and alumina abrasives for the first half of 1918 are: Manufactured, 34,974 short tons; material sold or used, 33,794 short tons; and stock in hands of producers June 30, 29,061 short tons. As compared with the first half of 1917, there was an increase in production of nearly 60 per cent. The production in the first half of 1918 was approximately equal to 62 per cent of that for the whole year 1917.

## Consumption of Chlorine Bleach Curtailed

SPECIFIC reductions in the use of chlorine bleach in any form in the pulp and paper industry have been agreed upon by the Pulp and Paper Division of the War Industries Board and will shortly become legally effective as follows:

### SULPHITE PULP

The use of chlorine by any individual user in the bleaching of sulphite pulp is restricted to an amount not greater than 40 per cent of the amount now being used; that is to say, the amount of chlorine contained in 35 per cent commercial bleaching powder now used per 100 pounds of sulphite pulp will be computed and the user will be allowed 40 per cent of this amount in each 100 pounds of sulphite pulp hereafter bleached. Variation in the use of bleach per 100 pounds of sulphite pulp is permitted for the purpose of maintaining uniform color, provided the average used per 100 pounds of the pulp bleached does not exceed the permitted use of bleach per 100 pounds.

### SODA PULP

The use of chlorine by any individual user in the bleaching of soda pulp is restricted to an amount not greater than 70 per cent of the amount now being used; that is to say, the amount of chlorine contained in 35 per cent commercial bleaching powder now used per 100 pounds of soda pulp will be computed and the user will be allowed 70 per cent of this amount in each 100 pounds of soda pulp hereafter bleached. Variation in the use of bleach per 100 pounds of soda pulp is permitted for the purpose of maintaining uniform color, provided the average used per 100 pounds of the pulp bleached does not exceed the permitted use of bleach per 100 pounds.

### SULPHATE PULP

The use of chlorine in the bleaching of sulphate pulp is specifically forbidden.

### OLD PAPERS, ALL KINDS

The use of chlorine in the bleaching of recovered old papers is restricted to 0.35 per cent of stock.

# Chemical Control of Water Softeners

## A Discussion of the Reactions Involved in the Lime-Soda-Ash Process and the Derivation of a Practical and Simple Field Routine Analysis

By LOUIS F. CLARK

THE process of softening water by the use of the reagents, calcium hydrate or oxide, lime, together with sodium carbonate, soda ash, is a venerable one. The fundamental chemistry of the process and the machinery by which it is applied, may be found described in textbooks on analytical chemistry. Local conditions, however, often demand a special and convenient method of control for the process. The method as herein set forth has been evolved by reason of the following conditions:

1.—The water to be treated is subject to seasonal variation.

2.—The water is treated at widely distributed stations, so that the various machines require individual regulation.

3.—The lime used in the machines has a variable CaO content depending on the degree of calcination.

4.—The soda ash ranges from 45 to 90 per cent Na<sub>2</sub>CO<sub>3</sub>, according to the time it has effloresced in dry air.

5.—The operation of the individual softening machines must be controlled by an operator who can make field tests to determine the proportions of materials required.

6.—The equipment for conducting the tests must be simple and portable.

7.—The operator usually will have available only the water to be softened, as he will carry no distilled water.

An average analysis of the hard water to be softened will show that it is of such composition that any substitution process, whereby the scale-forming alkaline earth salts are precipitated and those of sodium substituted, will leave such an enormous amount of material in solution after treatment that evaporation residues will require frequent removal. Thus it is urgent that the individual softening machines receive careful regulation to avoid possible excesses when precipitants of such variable composition are in use.

### AN AVERAGE WATER ANALYSIS

|                     | Million | Grains,<br>U. S. Gal. |
|---------------------|---------|-----------------------|
| Silica              | 28.0    | 1.63                  |
| Sodium Chloride     | 156.2   | 9.11                  |
| Magnesium Chloride  | 19.2    | 1.12                  |
| Magnesium Sulphate  | 318.1   | 20.32                 |
| Calcium Sulphate    | 618.0   | 36.04                 |
| Calcium Bicarbonate | 202.0   | 11.78                 |
|                     | 1371.8  | 80.00                 |

Hardness tests on water by the use of soap solutions do not determine the exact quantities of reagents necessary for softening. A field analysis may be made by titration of the water with a suitable HCl solution, together with proper additions of the various reagents actually used in the softening process. It is of first importance that the HCl solution used should be of such strength that in any titration the operator can read directly from the burette in pounds per 1000 gallons, or a simple multiple thereof, because the machines require the weight of the precipitants in pounds for each 1000 gallons of water to be treated.

The most satisfactory report of a water analysis is given when the components are expressed as parts per million. If we accept the specific gravity of the water as unity, we may accept milligrams per liter as equal to parts per million. By the relation of weights we can arrive at the factor,<sup>1</sup> 0.0583, by which parts per million should be multiplied to give grains per U. S. gallon; further if we consider gms. of materials in solution in 100 cc., we may multiply such weight by 83.3 and get pounds per 1000 gallons.

Other points it is necessary to consider here are that, as will be subsequently shown, it is convenient to consider the lime as having a certain percentage of CaO content rather than Ca(OH)<sub>2</sub>, even though the material has been slaked, by reason of the fact that the molecular weight of CaO (56) is nearly equal to one-half the molecular weight of Na<sub>2</sub>CO<sub>3</sub> (106), at least sufficiently near, that our HCl solution can be adjusted so that its factor for lime will be one-half its factor for soda ash. Finally, the calcium in solution in this water in excess of that satisfied by the mineral acids is regarded as being in solution as bicarbonate, not carbonate. Basicity determination on the water on this assumption checks the value of calcium so existing, calculated from a complete analysis.

With these points in view we can proceed to calculate the strength of hydrochloric acid solution required.

Assume K = gms. Ca(HCO<sub>3</sub>)<sub>2</sub> in 100 cc. raw water.

Let x = gms. CaO required to ppt. K as CaCO<sub>3</sub>.

As x : K :: 56 : 162,  
x = 0.345 K.

Let Y = gms. HCl equivalent to K in titration.

Y : K :: 72.9 : 162.  
Y = 0.45 K.

By derivation as given in a previous paragraph  
x (83.3) = X, lb. lime per 1000 gal.

∴ X = (83.3) (0.345) K = 28.75 K lb. CaO required per 1000 U. S. gallons, but with a 100-cc. sample of water, Y = 0.45 K.

And Y must = 28.75 K cc. so that burette will read lb. per 1000 gallons.

Hence Y = 0.45 K gms. HCl existing in 28.75 K cc. of acid, or 1 cc. = 0.01565 gm. HCl.

This acid solution has been found too strong for use and one-fourth this strength has been arbitrarily adopted. If we make an HCl solution so that 1 cc.

$\frac{0.01565}{4} = 0.00391$  gm. HCl, then the equivalent of 1 cc. in CaO equals (0.00391) (56) ÷ 72.9 = 0.0030 gm. and the equivalent in soda ash of 1 cc. equals

<sup>1</sup> 83.3 (lb. in U. S. gal.) × 7000 (gr. in lb.) ÷ 1,000,000 = 0.0583.



$(0.00391)(106.1) \div 72.9 = 0.0057$  gm.  $\text{Na}_2\text{CO}_3$ , but if the molecular weight of  $\text{Na}_2\text{CO}_3$  were exactly equal to twice the molecular weight of  $\text{CaO}$ , then we should have found that 1 cc. of the  $\text{HCl} = 2(0.0030) = 0.0060$  gm.  $\text{Na}_2\text{CO}_3$  instead of 0.0057 gm.  $\text{Na}_2\text{CO}_3$ .

If 1 cc. of the  $\text{HCl} = 0.0060$  gm.  $\text{Na}_2\text{CO}_3$ , then 1 cc. of  $\text{HCl} = 0.00413$  gm.  $\text{HCl}$  instead of 0.00391 gm. Let us take an average,  $(0.00413 + 0.00391) \div 2 = 0.00402$  gm.  $\text{HCl}$  required to the cc.

Such a solution can be made by using 1 cc. of concentrated acid per 100 cc. of distilled water and adjusted by titration against standard  $\text{Na}_2\text{CO}_3$  solution.

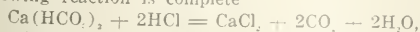
We arrived at the calculated strength of this acid solution by assuming titration on a 100-cc. sample. With such a sample, therefore, 1 cc. of this acid is equivalent to  $\frac{1}{3}$  lb. of  $\text{CaO}$  or  $\frac{1}{3}$  lb. of  $\text{Na}_2\text{CO}_3$ . These are the simple multiples referred to above.

This solution of  $\text{HCl}$  is prepared at the central laboratory and carried with the field apparatus. In order to make the field tests, the operator is preferably equipped as follows:

1. One 2-liter bottle of standard  $\text{HCl}$  solution.
2. One 50-cc. burette.
3. One balance to weigh out 10-gm. samples.
4. One 100-cc. graduate.
5. Two funnels. Filter paper.
6. Two 200-cc. Erlenmeyer flasks.
7. One glass tube 20 in. long and suitable single hole stopper to fit the Erlenmeyer.
8. Two 200-cc. beakers.
9. One oil burner to heat solutions.
10. One pound of ammonium chloride.
11. Solutions of methyl orange and phenolphthalein indicators.
12. One small mortar and pestle.

The above equipment comprises the portable laboratory which the operator can carry from station to station for making tests on the individual machines. In making these tests there are two general possibilities in connection with the use of  $\text{CaO}$  and  $\text{Na}_2\text{CO}_3$  with the water to be softened. Theoretically the  $\text{CaO}$  should only be used to precipitate the  $\text{Ca}(\text{HCO}_3)_2$  as  $\text{CaCO}_3$ , leaving the calcium and magnesium sulphates to be precipitated as carbonates by the  $\text{Na}_2\text{CO}_3$ . However, in cold solution  $\text{Na}_2\text{CO}_3$  does not completely precipitate magnesium as  $\text{MgCO}_3$ , because of the formation of soluble magnesium bicarbonate. This may be prevented by introducing excess lime to the point of completely precipitating all the magnesium as hydrate and to form a protective alkalinity so as to avoid the possibility of magnesium bicarbonate formation. When this condition is established, the magnesium is completely precipitated in the cold by the  $\text{Na}_2\text{CO}_3$ . Obviously such a procedure is more expensive, because the excess  $\text{CaO}$  so used must be thrown out by using its equivalent of  $\text{Na}_2\text{CO}_3$ , so that for each  $\text{Mg}(\text{OH})_2$  precipitated one calcium ion goes into solution as sulphate. However, the additional cost incurred by this excessive use of  $\text{CaO}$  is small compared to the benefit derived from the more complete removal of magnesium from the boiler water. On this basis therefore the following procedure is set down:

As  $\text{Ca}(\text{HCO}_3)_2$  is alkaline to methyl orange until the following reaction is complete



Therefore—(a) Take 100 cc. raw water, add 2 drops of methyl orange. (b) Titrate cold = A cc. of standardized  $\text{HCl}$ .

We may divide A, cc. by 4 and find the pounds of chemically pure  $\text{CaO}$  required per 1000 gallons of raw water to precipitate all the  $\text{Ca}(\text{HCO}_3)_2$  as  $\text{CaCO}_3$ . But for the present, we note down A, cc. and divide by 2 to obtain the pounds per 1000 gallons of  $\text{CaO}$  required, which will be explained later.

Since 1 cc. of  $\text{HCl}$  solution equals  $(0.00402 \div 72.9) 56 = 0.00309$  gm.  $\text{CaO}$ , if it were possible, we might put 0.1545 gm. of chemically pure  $\text{CaO}$  into 100 cc. of distilled water and titrate the mixture with exactly 50 cc. of  $\text{HCl}$  solution. Further, we could multiply the amount used by 2 and read 100 per cent as the purity of  $\text{CaO}$ . Similarly we can put 0.1545 gm. of any lime into 100 cc. of distilled water, titrate and multiply the cc. used by 2 and get the per cent of  $\text{CaO}$  in the lime. Putting 0.1545 gm. into 100 cc. is the same as putting 10 gm. into 6470 cc., a procedure practicable in the field. However, as there is no distilled water to be had outside of the laboratory the 100 cc. of the raw water will react with the equivalent of A, cc. expressed as c.p.  $\text{CaO}$ . For each 100 cc. of the 6470 cc., therefore, this amount of c.p.  $\text{CaO}$  is precipitated as  $\text{CaCO}_3$ . Further we know that when we put this amount of lime into such water, some very insoluble  $\text{Mg}(\text{OH})_2$  is precipitated. Thus the simple addition of lime to the water, boiling, cooling and titrating with phenolphthalein does not usually give a sufficiently sharp end-point. For this reason, let us take about 150 cc. of this mixture, boil, cool and add  $\text{NH}_4\text{Cl}$ . Then any  $\text{Mg}(\text{OH})_2$  will go into solution as  $\text{MgCl}_2$  and yield an equivalent amount of  $\text{NH}_4\text{OH}$ . We can now filter this solution free from  $\text{CaCO}_3$  on the assumption that the boiling has rendered the  $\text{CaCO}_3$  crystalline and scarcely at all soluble in the  $\text{NH}_4\text{Cl}$  solution. Take 100 cc. of the filtrate, add 2 drops of methyl orange and titrate to get A, cc.

Put 10 gms. of lime into 6470 cc. of water and mix well.

Take about 150 cc. of well-agitated mixture into a flask (boil under condenser and cool).

Add  $\text{NH}_4\text{Cl}$  to the cold mixture in the flask.

Thoroughly agitate, settle for 15 minutes and filter cold.

Take 100 cc. of filtrate for titration which takes A, cc. of acid. Then:  $2(A_1 + A_2) =$  per cent of  $\text{CaO}$  in the lime.

This summation  $A_1 + A_2$  represents the number of cc. of acid that would have been used in the titration, were it possible to conduct the operation in distilled water. Note also that no distilled water was used in the manipulation.

If we had not added the  $\text{NH}_4\text{Cl}$  to the above mixture but had filtered the mixture at once, a titration of the filtrate would have revealed the  $\text{CaO}$  in solution, which had not been used either to precipitate  $\text{Ca}(\text{HCO}_3)_2$  as  $\text{CaCO}_3$  or  $\text{MgSO}_4$  as  $\text{Mg}(\text{OH})_2$ . Then since  $A_1 + A_2$  represents the total  $\text{CaO}$  added, we subtract  $A_2$ , the excess of  $\text{CaO}$  added, and divide by 4 to find the pounds of chemically pure  $\text{CaO}$  required per 1000 gallons of water treated. This is of course based on the assumption that there is sufficient volume of water used to dissolve all the  $\text{CaO}$  existing in the 10 gms. of lime added and that no precipitation of  $\text{CaO}$  occurs from atmospheric  $\text{CO}_2$  during the manipulation. These conditions do not always exist. Hence the value of total  $\text{CaO}$  required, found in this way, should merely be

regarded as a guide. Further it should be remembered that this is the extreme limit of the requirements for CaO. It is not necessary to use enough CaO to precipitate all the  $\text{MgSO}_4$ , as  $\text{MgOH}$ , it is only desirable to partially accomplish this, so as to have alkalinity enough to prevent the formation of magnesium bicarbonate. Therefore it is advisable to but slightly exceed the  $\frac{1}{2}A$  value for CaO. This condition for raw water is usually reached when  $2\frac{1}{2}A$  or  $\frac{1}{2}A$  lb. c.p. CaO per 1000 gallons are used. The value found at  $A_3$  is merely noted for a check on lime consumption.

Take about 150 cc. of well-agitated lime mixture.

Filter without addition of  $\text{NH}_4\text{Cl}$ .

Titrate 100 cc. of filtrate =  $A_3$  cc. HCl solution.

Then:  $(A_1 + A_2 - A_3) \div 4$  equals pounds per 1000 gallons of c.p. CaO required, subject to the minor variations mentioned above.

One cc. of the HCl solution equals  $(0.00402 \div 72.9) (106.1) = 0.00585$  gms.  $\text{Na}_2\text{CO}_3$ . If we put 0.2925 gms. c.p.  $\text{Na}_2\text{CO}_3$  (anhydrous) into 100 cc. of distilled water and titrate it using methyl orange as an indicator with exactly 50 cc. of the HCl solution, we could multiply the cc. of acid so used by two and prove the material to be 100 per cent. Similarly, when we add 0.2925 gm. of any soda ash to 100 cc. of distilled water or 10 gms. to 3420 cc. and titrate 100 cc. of the solution, we find the percentage of  $\text{Na}_2\text{CO}_3$  by multiplying the cc. used by two. Usually there is no distilled water in the field supplies but since 100 cc. of crude water is equivalent to  $A_1$  cc. of acid solution because of its bicarbonate alkalinity; hence, if the titration of this solution requires  $A_1$  cc. we can say  $2(A_1 - A_2)$  the per cent of  $\text{Na}_2\text{CO}_3$  in the soda ash. It should be noted that this solution of soda ash added to the raw water will cause a precipitation of all the calcium existing as  $\text{CaSO}_4$ , etc., and of at least part of the magnesium. The  $\text{Ca}(\text{HCO}_3)_2$  is not affected. If we agitate the mixture well and take a 100-cc. sample to which a pinch of  $\text{NH}_4\text{Cl}$  has been added to dissolve the  $\text{MgCO}_3$ , the  $\text{CaCO}_3$  precipitate is crystalline and alkaline to methyl orange. It is advisable to add the acid slowly near the end point so as not to exceed the  $\text{CaCO}_3$  equivalent.

Put 10 gms. of soda ash into 3420 cc. of water.

Agitate well and take 100 cc. of the mixture.

Add  $\text{NH}_4\text{Cl}$  to 100 cc. of mixture.

Add 2 drops of indicator and titrate, which takes  $A_1$  cc. of the acid solution.

Then:  $2(A_1 - A_2)$  equals the per cent of  $\text{Na}_2\text{CO}_3$  in the soda ash.

If 100 cc. of raw hard water were treated with a given weight of c.p. anhydrous  $\text{Na}_2\text{CO}_3$  and the solution evaporated to dryness, taken up in distilled water, filtered and titrated, we could determine the  $\text{Na}_2\text{CO}_3$  consumed in precipitating the calcium and magnesium sulphates, etc. The  $\text{Ca}(\text{HCO}_3)_2$  is decomposed and precipitated as  $\text{CaCO}_3$  by the evaporation. Such a process can not be conveniently carried out in the field. However, when the CaO is added to the 6470-cc. portion of the water, it precipitates  $\text{Ca}(\text{HCO}_3)_2$  as  $\text{CaCO}_3$  and  $\text{MgSO}_4$  as  $\text{Mg}(\text{OH})_2$ . For each equivalent of magnesium so precipitated, one of calcium goes into solution as sulphate. Therefore, when  $\text{Na}_2\text{CO}_3$  is subsequently added to this mixture, the same amount of  $\text{Na}_2\text{CO}_3$  is consumed to precipitate the newly formed  $\text{CaSO}_4$ , as would have been required to precipitate the original

$\text{MgSO}_4$ . As far as the total alkalinity of the filtrate is concerned, it is not important whether the  $\text{MgO}$  is changed to  $\text{MgCO}_3$  or not. If the carbonate precipitation is conducted in a solution containing any free alkali, then bicarbonate does not form, and the magnesium is completely precipitated in the cold. Also if to any solution containing CaO an excess of  $\text{Na}_2\text{CO}_3$  is added and the solution filtered, the total alkalinity of the filtrate is equal only to the alkalinity of the  $\text{Na}_2\text{CO}_3$  introduced, and the original alkalinity due to CaO remains on the filter paper as  $\text{CaCO}_3$ . On this basis then we can take 3420 cc. of the lime mixture already prepared, add 10 gms. of the same soda ash used at  $A_1$ , agitate well, settle, filter, and titrate 100 cc. to get  $A_3$  cc. Under these conditions the magnesium is completely precipitated as carbonate in the cold, due to the presence of the NaOH or CaO which prevents the formation of magnesium bicarbonate.  $\frac{1}{2}(A_1 - A_2 - A_3) =$  lb. of c.p.  $\text{Na}_2\text{CO}_3$  per 1000 gallons required for reacting with Ca and Mg sulphates.

Agitate lime mixture made at  $A_1$ .

Measure off 3420 cc. of this lime mixture and add 10 gms. soda.

Agitate well and settle.

Filter and titrate 100-cc. portions which equals  $A_3$  cc.

At this point we might mention that some prefer to describe water in terms of degrees of temporary and permanent hardness. As a basis for discussion we might define for ourselves one degree of hardness as 1 mg. per liter of  $\text{CaCO}_3$ . The degrees of temporary hardness are those dispelled by boiling or the parts per million of  $\text{Ca}(\text{HCO}_3)_2$ , expressed as  $\text{CaCO}_3$ . Then since we can theoretically express any salt by its chemical equivalent, weight of  $\text{CaCO}_3$ , by manipulation of the

relative molecular weights, we can say:  $\frac{120 \times 100}{4 \times 56} A_1 = 53.5 A_1$ , = degrees of temporary hardness, where 120 is the reciprocal of 0.00835, the number of which mg. per liter must be multiplied to give pounds per 1000 gallons, and 56 is the molecular weight of CaO and 100 of  $\text{CaCO}_3$ . Moreover, since the amount  $(A_1 - A_2 - A_3) \div 2$  found at  $A_3$  may be considered as the  $\text{Na}_2\text{CO}_3$  required to precipitate the Ca and Mg mineral acid salts and since we regard the molecular weight of  $\text{Na}_2\text{CO}_3$  as twice that of CaO we may write

$\frac{100 \times 120}{4 \times 56} (A_1 - A_2 - A_3) = 53.5 (A_1 - A_2 - A_3)$  = the calcium and magnesium mineral acid salts expressed as  $\text{CaCO}_3$  = degrees of permanent hardness. It may be urged that these degrees of hardness be determined by the use of a standard soap solution and calculation of softening reagents required made therefrom. Such determinations have not been found reliable nor anywhere near as extensive in the information conveyed as is required in this work.

As a further demonstration upon the action of the softening machines, we see from the following equations that reagents can be weighed in grams and put into 8.35 liters of water. The same conditions will obtain then as in the case of using pounds per 1000 gallons. Thus the operation can be observed on a small scale.

1 lb. per 1000 gal. = 453.6 gm. per 3785.4 liters =  
1 gm. per 8.35 liters.

Another set of tests may be made upon the machines in operation. Consider the liquid which issues from the lime tank. This is milk of lime emulsion and contains CaO in solution. Also CaO,  $\text{CaCO}_3$ , and  $\text{Mg}(\text{OH})_2$  are in suspension. It must be a milk of lime, not merely a solution, in order to convey in a small volume a sufficient amount of CaO for the entire volume of water under treatment. Such an amount is in excess of the solubility of CaO in the small volume of water passing through the lime tank. Hence what we want to know in such an emulsion is its actual content per 1000 gallons of  $\text{MgO}$  and CaO in solution and suspension. Here again we can use  $\text{NH}_4\text{Cl}$  under conditions as previously described. Thus we take about 150 cc. of this mixture, boil to render  $\text{CaCO}_3$  crystalline, cool, add  $\text{NH}_4\text{Cl}$ , agitate and settle. This will dissolve  $\text{Mg}(\text{OH})_2$ , and permit any CaO in suspension to go into solution. We can filter such a mixture, leave the  $\text{CaCO}_3$  on the paper and titrate 100 cc. of the filtrate which equals  $B_1$  cc. We know that  $B_1$  cc. includes  $\text{Mg}(\text{OH})_2$  precipitated by CaO but this makes no difference for it represents alkali nevertheless.

Take a 150-cc. sample of the emulsion issuing from lime tank. Boil, cool, add  $\text{NH}_4\text{Cl}$ , agitate and filter.

Titrate 100 cc. of filtrate to get  $B_1$  cc.

$B_1 \div 4 =$  pounds c.p. CaO issuing in each 1000 gallons that flows out of this tank.

It may be advisable to know the condition of the water as it completes its journey through the softening machines. A sample may be taken above the filters. The procedure is nearly the same as at  $A_1$ . Treat a 3420-cc. sample with a small amount of lime (2 gms.) to render alkaline and proceed as if it had no previous addition of  $\text{Na}_2\text{CO}_3$ . Carry through the determination exactly as if it were the  $A_1$  lime mixture. Filter the liquid after boiling under the reflux condenser as before and titrate 100 cc. which will give  $B_2$  cc. We know that at the time these tests are made the procedure of putting 10 gms. of soda into 3420 cc. of water introduces an equivalent of  $(A_1 - A_2)$  in terms of c.p.  $\text{Na}_2\text{CO}_3$ . If we titrate the liquid from this test and find it to be  $B_2$  cc. we can write:  $\frac{1}{2}(B_2 - A_1 + A_2) = \pm \text{lb. per 1000 gallons of c.p. Na}_2\text{CO}_3$ . The plus or minus sign in the result is important because: If  $B_2$  is greater than  $(A_1 - A_2)$  then the sign is plus and we know that there was free sodium carbonate in the solution at the time that test was made, and exactly as much as is expressed by the solution of the equation.

If  $B_2$  is less than  $(A_1 - A_2)$  then the sign is minus and we know that there was an insufficient amount of  $\text{Na}_2\text{CO}_3$  present to complete the precipitation of the alkaline earth salts by the exact amount shown by the solution of the equation.

Take 3420 cc. of water above filters, and add about 2 gm. of lime.

Add 10 gms. of soda ash on which  $(A_1 - A_2)$  has just been determined.

Agitate well and settle as with  $A_1$ .

Filter and titrate 100 cc. to get  $B_2$ .

Then,  $(B_2 - A_1 + A_2) \div 2 = \pm \text{lb. per 1000 gallons c.p. Na}_2\text{CO}_3$ .

If positive, lb. per 1000 gallons excess present.

If negative, lb. per 1000 gallons short.

This is an identical procedure as for  $B_1$  and is made upon the water storage tanks. It may often be possible

to make slight corrections by additional reagents even after the water has entered the storage tank. Though these methods may seem complicated and perhaps are somewhat theoretical, the practical directions as issued to the operator are simple and may be summarized as follows:

#### *Directions to operator*

$A_1$  Take 100 cc. raw water, add 2 drops of indicator. Titrate cold with HCl solution =  $A_1$  cc. ( $\frac{1}{2}A_1 =$  lb. per 1000 gal. c.p. CaO required. This figure divided by the per cent of CaO gives lb. per 1000 gallons crude lime required).

$A_2$  Put 10 gms. crude lime into 6470 cc. of water and agitate.

Take about 150 cc. of well-agitated mixture into a flask, boil and cool.

Add a small amount (2 grains) of  $\text{NH}_4\text{Cl}$  to the cold mixture in the flask.

Stir mixture in flask well and filter cold.

Titrate 100 cc. of filtrate in the cold with HCl solution =  $A_2$  cc.

Then:  $\frac{1}{2}(A_1 + A_2)$  per cent CaO in the crude lime.

$A_3$  Take about 150 cc. of the above well-agitated lime mixture.

Filter without addition of  $\text{NH}_4\text{Cl}$ .

Titrate 100 cc. of filtrate with HCl =  $A_3$  cc.

Then:  $(A_1 + A_2 - A_3) \div 4 =$  lb. per 1000 gal. c.p. CaO required by the water. (This figure divided by the per cent of CaO gives lb. per 1000 gallons of crude lime required, when the absolute limit of lime consumption is wanted.)

$A_4$  Put 10 gms. soda ash into 3420 cc. of water.

Agitate well and take 100 cc. of mixture.

Add a pinch of  $\text{NH}_4\text{Cl}$  to the 100-cc. mixture.

Titrate in the cold with HCl solution =  $A_4$  cc.

Then:  $2(A_4 - A_1) =$  per cent of  $\text{Na}_2\text{CO}_3$  in the soda ash.

$A_5$  Agitate lime mixture made at  $A_1$ .

Measure off 3420 cc. of this lime mixture and add 10 gms. soda ash.

Agitate well and settle.

Filter and titrate 100-cc. portions with HCl solution =  $A_5$  cc.

Then:  $(A_4 - A_1 - A_5) \div 2 =$  lb. per 1000 gallons c.p.  $\text{Na}_2\text{CO}_3$  required by the raw water. This figure divided by the per cent of  $\text{Na}_2\text{CO}_3$  found at  $A_4$  gives the lb. per 1000 gallons of crude soda ash required.

#### *Solutions from lime tank*

(a) Take 150 cc. of sample of emulsion issuing from lime tank.

(b) Boil, cool, add  $\text{NH}_4\text{Cl}$  and filter.

(c) Titrate 100 cc. of filtrate with HCl solution =  $B_1$ .

Then:  $\frac{1}{2}B_1 =$  lb. c.p. CaO issuing in each 1000 gallons out of this tank.

#### *Sample taken above the filters*

(a) Take 3420 cc. of water, add 10 gms. soda ash and about 2 gms. of lime. (This must be same soda ash used at  $A_4$ , etc.)

(b) Agitate well and settle mixture as for  $A_4$ .

(c) Filter and titrate 100 cc. of filtrate cold =  $B_2$ .

Then:  $(B_2 - A_1 + A_2) \div 2 = \pm \text{lb. per 1000 gal. c.p. Na}_2\text{CO}_3$ . + = excess, - = deficiency.

Potrerillos, Chile.



# Mobile Chlorine Water-Purification Plant

Trucks Equipped with Mechanical Filter, Chlorinating Apparatus and Testing Laboratory  
Sterilize Water for Troops

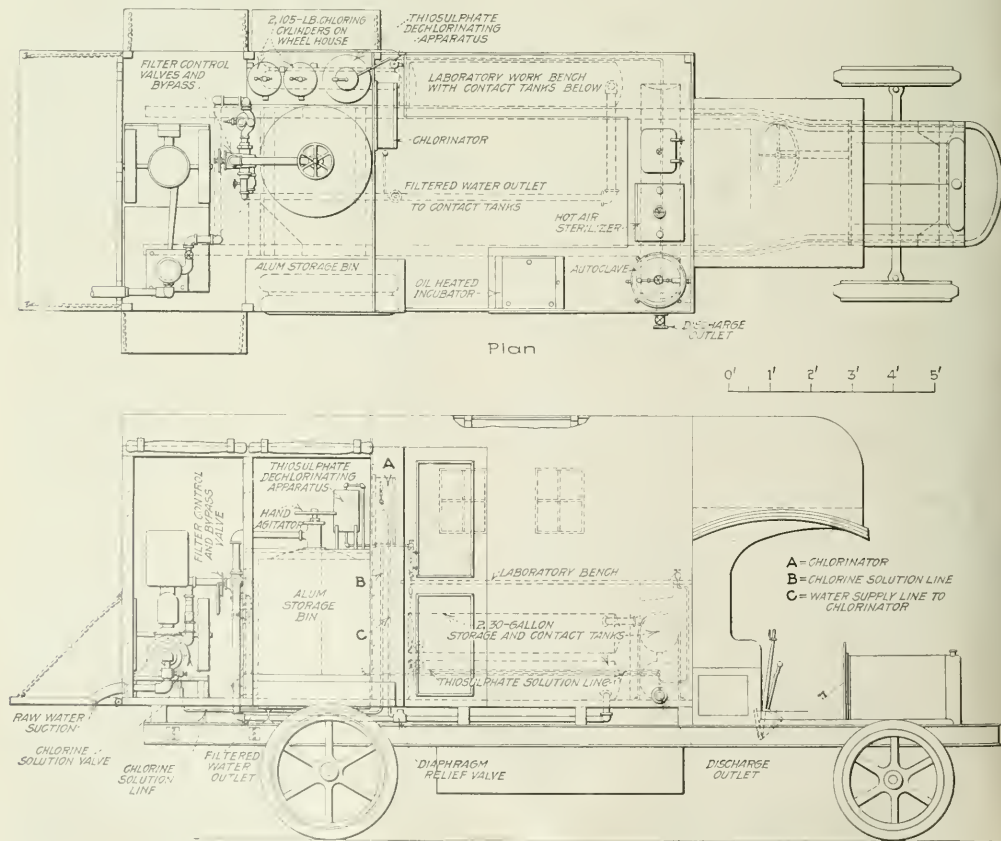
BY ROBERT K. TOMLIN, JR.

War Correspondent of Chemical & Metallurgical Engineering

FOR emergency filtration, sterilization and analysis of water supplied to American troops at the front in France, specially designed mobile plants, mounted on standard motor trucks, have been placed in service. The first outfits of this sort were sent to a division in an American sector early in June. They are the forerunners of others which, it is planned, will be used pretty generally by the American Expeditionary Forces for producing temporary supplies of potable water pending the creation of the more or less permanent "water points" which present military engineering practice has developed for the advance zones. While they embody no principles of water treatment which have not been employed for years past in the United States, the portable

plants are nevertheless unique in so far as sanitary engineering practice of the allied armies is concerned. They represent an ingenious adaptation of standard American methods of water purification, on a comparatively large scale, to the special needs of Army service, the features of the new outfits being mobility and such compactness in arrangement that a complete water purification plant and analytical laboratory are carried on the chassis of a 3-ton truck.

The details of the "Steri-Lab" truck are shown in the accompanying drawing and photographs. At the rear end is a gasoline-driven pump of the double-acting piston type with a rated capacity of 20 gal. per minute which may be operated against a pressure of 100 lb. per

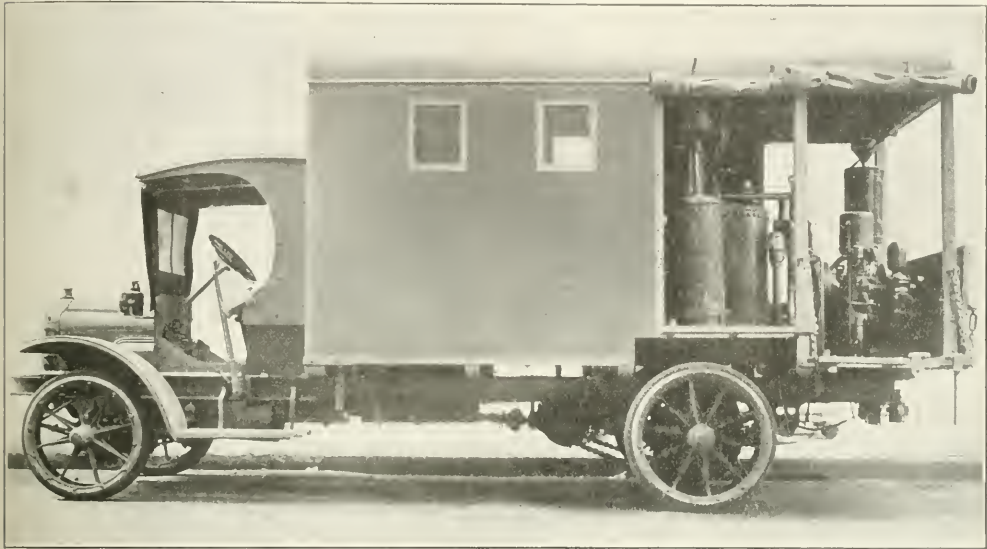


Elevation  
SIDE ELEVATION AND PLAN SHOW DETAIL OF MOBILE WATER-PURIFICATION PLANT

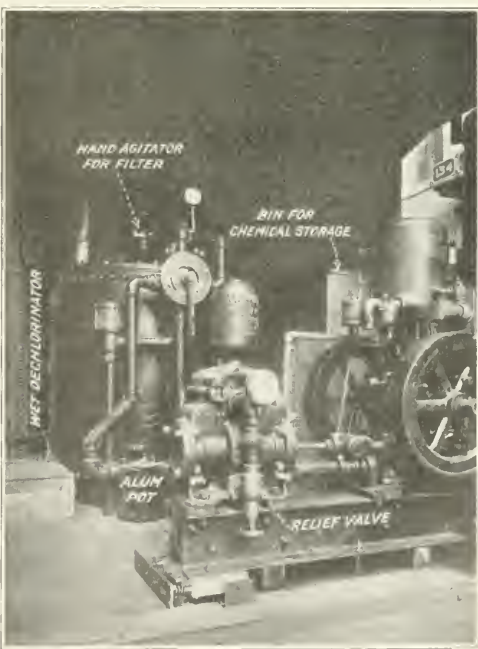
square inch. It is equipped with 50 ft. of 2-in. hose, foot-valve and strainer. The pump delivers direct to a Roberts mechanical filter of the pressure type, a 30-in. diameter vertical tank mounted over the rear axle. This filter has a hand agitator and is fitted with an alum pot.

An alum storage bin is mounted over the right rear wheel of the truck.

There are at the present time three different types of these motor-truck plants. The first is known as the "Steri-Lab" and comprises a pump, a pressure filter, a



ALL THE STERI-LAB EQUIPMENT IS COMPACTLY ARRANGED AND CARRIED ON A THREE-TON TRUCK



CORNER OF WATER ANALYSIS LABORATORY—PUMPING PLANT, PRESSURE FILTER AND DECOLORINATOR

chlorinating apparatus and a laboratory. The second, the "Chloro-Pumping" outfit, is like the first, except that it carries no pressure filter, and has a pump of greater capacity than the "Steri-Lab." The third is essentially a laboratory on wheels for the chemical and bacterial analysis of water. These mobile plants were designed and equipped by the Wallace & Tiernan Co., Inc., of New York, working in collaboration with officers of the Corps.

Chlorine gas is applied at the pump suction, and the dose generally is much heavier than that employed in ordinary municipal water-works practice. It may vary from 4.5 to as much as 10 parts per million. A contact period of from 10 to 15 minutes is afforded by cylindrical tanks mounted under the work bench of the laboratory compartment of the outfit. With such an intensive application of chlorine, which is adopted to insure absolute safety in the quality of the treated water, it will frequently be necessary to dechlorinate with a thiosulphate solution applied through an adjustable sight feed. The chlorine is carried in 105-lb. cylinders. To a large extent our water-supply sterilization will be carried on with chlorine obtained from the gas service of the American Expeditionary Forces.

The filtered and sterilized water passes either to a discharge valve, where it can be fed to tank carts or stationary storage, or it may be left in the contact tanks for storage there. These four tanks have a capacity of 30 gal. each, and are tested for a pressure of 100 lb. per square inch.

The forward part of the truck body is occupied by the testing laboratory. This room is completely inclosed, and provided with a door from the rear and wire-glass windows on the side. It is completely equipped as a water-testing laboratory, with working bench, wash sink, water under pressure through faucets, hot air sterilizer for sterilizing water, autoclave, etc.

This type of machine will be able to sterilize 1200 gal. of water per hour when operating through its full system. A bypass is provided around the filter, so that if a water supply is encountered which does not require filtration to remove turbidity and color, but simply chlorination to make the water bacteriologically safe, the capacity may be increased.

The second type of mobile plant, or "Chloro-Pumping" outfit, is carried on a 1½-ton instead of a 3-ton truck. Here there is no pressure filter. The pump has a capacity (40 gal. per minute) double that of the "Steri-Lab" machine. This outfit is designed for emergency work during an advance or a retreat where filtration may be dispensed with. The chlorinating and thiosulphate apparatus is of the same kind as that previously described.

The "laboratory," or third, type of truck is also carried on a 1½-ton chassis. It is fitted with the usual equipment for making chemical and bacteriological examinations of water. All racks and cases are felt-lined to prevent glass breakage. Water for laboratory use is contained in a tank fitted with a hand air pump to supply pressure. On this truck will be carried a bicycle for the use of the laboratory assistant in collecting samples.

### Domestic Chrome Ore Supply Satisfactory

The War Industries Board announces through Mr. Hugh W. Sanford, chief of the ferro-alloys section of the chemicals division, that the situation with regard to chrome ore in United States is well in hand.

## Washing in Filter Presses

By D. R. SPERRY

THOROUGH WASHING

THE most important and the most widely used method of washing employed in filter-presses is known as "thorough washing." This system of washing has also been called "every-other-plate system" from the fact that every other plate only has a wash inlet. "Back washing" is a term sometimes used because of the fact that the wash-water fills the space back of the cloths in contradistinction to simple washing where the wash-water enters between the cloths with the cake. "Through washing" has been used to denote this system probably from the incidence that the wash-water goes completely through the cake and both cloths. This term may also be a corruption of the word "thorough."

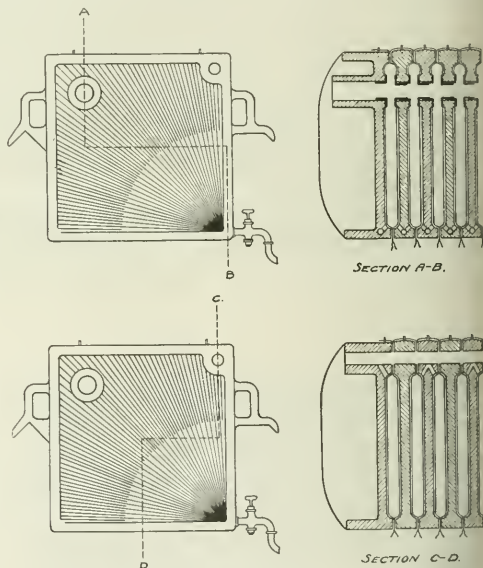


FIG. 1. CROSS-SECTION THROUGH RECESSED-PLATE FILTER-PRESS

Occasionally one hears the term "every-other-cock system," because in this system every other cock is closed.

### THOROUGH-WASHING IN RECESSED PLATES

In thorough-washing two different kinds of plates are used in each arrangement. The two kinds of plates are placed alternately in the filter press. The difference between the two plates lies in the fact that one has an inlet from the wash eye to both surfaces while the other has no inlet whatever from the wash eye to the interior. These plates are distinguished from each other by the terms "wash plate" and "non-washing plate" respectively. Fig. 1 is a cross-section through a recessed-plate filter-press. The upper cross-section passes through the feed channel while the lower passes through the wash channel.

The plates are clothed in the usual manner and placed in the filter press, first a non-washing plate, next a washing plate, and so on until the filter-press is com-



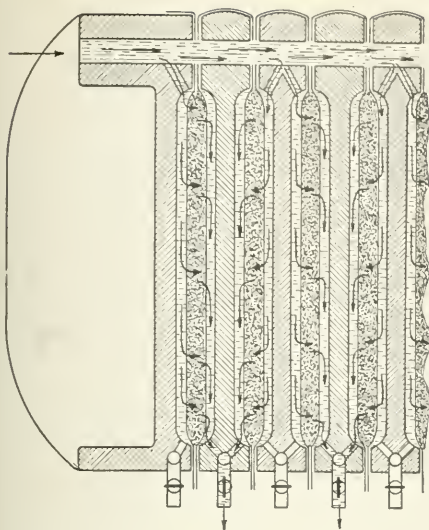


FIG. 2. PATH OF WATER IN THOROUGH-WASHING SYSTEM

pletely filled. In Fig. 1 the upper plate is a non-washing plate as there is no connection between the small upper-right-hand-corner eye and the interior of the plate. The lower is a washing plate because the small upper-right-hand eye has an inlet leading to both surfaces of the plate. In the thorough-washing system it should be borne in mind that the heads of a filter-press having an uneven number of plates are always different—one has an inlet from the washing channel and the other has not. Sometimes the stationary head is a wash-head, as shown in Fig. 1 (lower part), but it is just as likely to be a non-washing head depending upon the way the maker built the machine. In good practice, for reasons given later, filter-presses having an uneven number of plates have the stationary head, a washing-head, while if there is an uneven number of plates both heads are non-washing. However the heads may be, a non-washing plate must always come next to a washing-head as shown in Fig. 1, while a washing plate must always come in contact with a non-washing head. A head is non-washing if there is no connection between the wash eye and the surface of the head, while if there is such a connection as in Fig. 1, it is a washing-head. Filling of the filter-press is accomplished the same as was done in the plain recessed type, care being taken to see that the wash-inlet valve is closed and all cocks wide open. The material to be filtered, which is

pumped into the feed inlet, fills all the chambers formed by the plate recesses. As the liquid flows through the cloths bounding the chambers, the solids left behind fill the chamber completely, forming a cake. At this point the feed-inlet valve is closed and the pressure allowed to fall to zero. The cocks on all the washing plates and heads are then closed. The wash-water valve is then opened and the wash-water allowed to issue from the non-washing plate cocks. A study of Fig. 1 lower cross-section, shows that the wash-eyes form a continuous channel from one end of the filter-press to the other. When wash-water is forced into this channel it drops into only every other plate—the washing plates. In so doing it fills the space between the filter-base or cloth and the plate surface on both sides of the plate. The wash-water cannot pass directly out of the filter-press through the cocks because they are all closed on the washing plates. This being the case there is no way for the wash-water to get out except by passing through the cloth, through the solids and through the cloth on the non-washing plate. This is done with the result that the wash-water, after passing through both cloths and cake, emerges against the surface of the non-washing plate and passes downward and out through the cocks which purposely were left open on the non-washing plates.

In Fig. 2 an enlarged cross-section shows the path of the wash-water as used in the thorough-washing system. It will be noticed that since the cake through which the water must pass is twice the thickness through which the filtrate passed, the wash-water pressure must be greater than that used in filling the filter-press. Further reference to the proper washing pressure is given farther on. It should also be noted that the washing pressure is equal on both sides of the washing plates so that there is no danger of breaking plates by wash-water pressure. The pressure on both sides of the non-washing plates is also equal.

In Fig. 3 is shown a photograph of a washing plate of the recessed type. The picture is not large enough

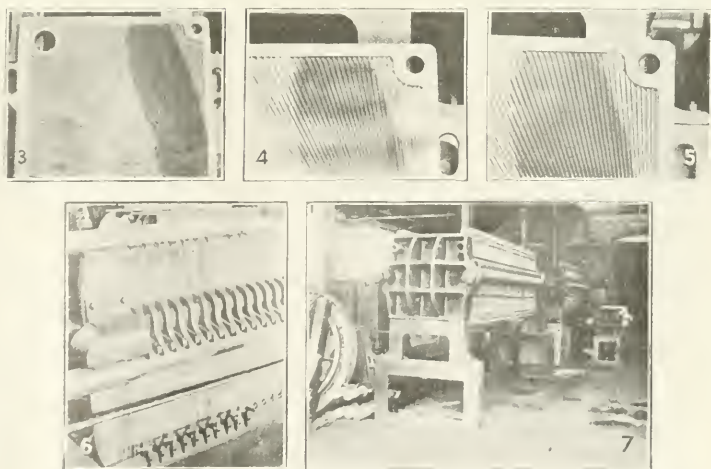


FIG. 3—RECESSED-TYPE WASHING PLATE. FIG. 4—WASHING PLATE. FIG. 5—NON-WASHING PLATE. FIG. 6—ARRANGEMENT OF COCKS FOR THOROUGH WASHING. FIG. 7—WASH AND FEED INLETS

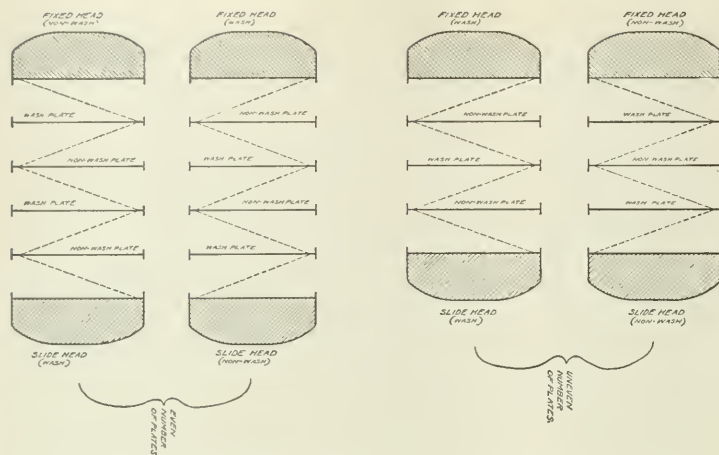


FIG. 8. PATHS OF WASH-WATER IN EVEN AND UNEVEN NUMBER OF PLATES

to show sufficient detail to distinguish whether or not there is an inlet from the wash part to the plate surface. If this plate were a washing plate a close-up photograph would disclose a wash-inlet as shown in Fig. 4. If, however, it were a non-washing plate the wash part would appear without an inlet to the plate surface as shown in Fig. 5. A photograph of a thorough-washing filter-press with the cocks arranged ready for washing is shown in Fig. 6. The wash and feed inlets of a wooden-plate thorough-washing filter press are shown in Fig. 7.

#### WASHING AND NON-WASHING HEADS

In Fig. 8 are two diagrams showing roughly the path of wash-water through filter-presses having, in the upper diagram, an uneven number of plates, and in the lower an even number of plates. In the case of an uneven number of plates it can be seen that neither head is a washing-head provided the stationary head is non-washing. On the other hand if the stationary head is made a washing-head, then both heads must be washing-heads. As it is more expensive to make a washing-head than a non-washing head, the first arrangement is best.

In the case of an uneven number of plates it can be seen that one head is always a washing-head. As it is less expensive to make the stationary head a washing-head than to make the movable head washing (due to the fact that it forms the end of the wash-channel) it is proper for an uneven number of plates to have the stationary head a washing-head.

#### PRESSURE IN WASHING

Since the flow through a filter-cake is non-sinuuous,<sup>1</sup> in which the velocity of the liquid through the capillary paths varies directly as the pressure and inversely as the length of the channel (in this case thickness of cake), it would appear as though twice as much pressure would be required for the wash-water, since it flows through cake twice as thick as that passed through

by the filtrate, providing a flow of wash-water is desired at least as great as that of the filtrate. In actual practice only 10 to 20 per cent greater pressure is required on the wash-water, in most cases, to produce a reasonable flow. In filling a filter-press the pressure is allowed to build up gradually until it reaches a predetermined maximum. This maximum pressure, if distributed over a cake one-half the thickness of the chamber would produce a flow far greater than that last observed issuing from the filter-press cocks. In the later stages of filling, the opposing cake surfaces gradually come in contact with each other, usually first at the bottom of

the chamber and extending upward. The last bow, therefore, is from a restricted area and not from the large area covered by the wash-water; hence double the feeding pressure is not required on the wash-water to produce a good flow equal to that of the filtrate.

Batavia, Ill.

### Fuller's Earth in 1917

The production of fuller's earth in 1917, as shown by a report published by the United States Geological Survey, Department of the Interior, was 72,870 short tons, valued at the mine at \$776,632 or \$10.66 a ton. The increase over 1916 was 5048 tons, or 7 per cent, and \$69,681, or nearly 10 per cent. Since its beginning, in 1895, this industry has almost steadily increased until, in 1917, its output and the value and average price per ton of its product were the highest yet attained.

Fuller's earth is found in many States, but in 1917 it was mined and marketed in only six. Florida was the leading producer in 1917, having been credited with more than three-fourths of the total output and value. The other States, named in order of production, were Georgia, Texas, Massachusetts, Arkansas, and California. The Southern States produced 98 per cent of the domestic fuller's earth marketed in 1917. The imports of fuller's earth, 16,994 short tons, also increased in 1917, but they formed only 19 per cent of the consumption. A few of the prominent domestic producers are: Floridin Co., Quincy, Fla.; General Reduction Co., Dry Branch, Ga.; Lester Clay Co., Jacksonville, Fla.; John Olson, Benton, Ark.

### The Present Status of Electric Brass Melting

In the article on this subject published in our issue for Sept. 15, page 321, several errors appear which affect the continuity of text. Line 17, column 2, page 324, should be followed by the matter appearing on line 10, column 1, page 327, to line 35, column 1, page 328, inclusive, which in turn should be followed by the matter from line 18, column 2, page 324, to line 9, column 1, page 327.

<sup>1</sup>The Principles of Filtration, by the author, in METALLURGICAL & CHEMICAL ENGINEERING, 15, 198-203 (1916) and 17, 161-166 (1917).

## Recent Chemical and Metallurgical Patents

**Removing Suspended TNT from Spent Acid.**—In the general practice of the TNT plants, large storage tanks are used to hold the spent nitrating acid during a separation process, when the minute crystals of nitro toluol held in suspension in the acid gradually gather at the top. The specific density of the crystals approaches so nearly that of the acid that the buoyant force is slight and long standing is necessary before the crystals rise to the top. Mr. FREDERICK M. G. JOHNSON of Montreal, Canada, has received a patent on a rapid and safe process for making this separation: 1000 lb. of spent acid is introduced into a vessel, which is hermetically sealed, and a vacuum of 25 inches of mercury created in the vessel above the material. Immediately minute bubbles of gas commence to collect on the particles of TNT suspended in the acid; these bubbles are presumably due to the vapor pressure of the nitric acid being greater than its internal hydrostatic pressure, so that the vapors gather at all the liquid surfaces, and the particles are ballooned up at a rapid rate to the surface. The cleared acid is drawn off from the bottom of the vessel, and the ton sludge transferred to a smaller vessel and heated sufficiently to melt the TNT and cause it to separate completely from the acid contained. With this method of separation, much less acid is kept in idle storage. (July 9—2,71,575.)

**Production of Aluminium.**—GEORGE GIULINI of Italy notes that in the reduction of alumina with carbon in an electric furnace but little metal is formed, the bulk of it remaining as oxide, plus some carbide and nitride. He therefore proposes to effect the reduction in an electric furnace under high vacuum, thus removing the carbon monoxide as rapidly as formed and preventing it from reacting with the vaporous metal as follows:



The volatile metal is also quickly removed from the proximity of the reducing agent, and therefore carbides are not formed to a great extent. (1,257,995; Mar. 5, 1918.)

P. R. HERSHMAN of Chicago, Ill., patents the method of reducing alumina (especially in the presence of oxides such as  $\text{SiO}_2$ , which materially reduce its melting point) by carbides either introduced as such or formed in the furnace at temperatures below the reduction point of the alumina. He specifies that the proper mixture be pressed into such form as to make the resistor of an electric furnace, and that the gaseous products of the reaction be immediately withdrawn from the furnace. It is also necessary that the reaction be carried out in a reducing atmosphere, consisting of hydrogen or hydrocarbons, and that the resulting metal be tapped shortly after its formation. As an essential constituent of the resistor he adds small amounts of finely divided aluminium, copper or other heat-conducting metals. (1,273,220; assigned to the Mineral Products Co.; July 23, 1918.)

**Separating Nickel from Copper.**—JOSEPH DHAVERNAS of New Brunswick, New Jersey, notes that when nickel-copper mattes are roasted to form copper oxides, which latter are to be removed by leaching, the removal of copper is never complete unless the roasting is sufficient to oxidize considerable quantities of the nickel as well. He therefore specifies that the roasting shall be followed by a reducing fusion, converting the mixture of oxides and sulphides into a low-sulphur matte containing considerable metallic materials. Nickels may now be removed from this mass by leaching with a slightly acid copper solution, any excess of copper remaining in the liquid being removed by precipitation on metallic nickel. (1,273,465; assigned to United States Nickel Co.; July 23, 1918.)

JULIUS H. GILLIS of Toronto, Canada, electrolyzes a nickel-sulphate solution, using a cathode of nickel and an anode of nickel-copper alloy containing about 60 per cent of the former metal. During the flow of the current, pure nickel at first deposits on the cathode, while copper and nickel both enter solution at the anode, the nickel in larger proportion owing to "selective action" and to the preponderance of this metal in the alloy. Before the copper ions have been transported any considerable distance from the surface of the anode, the current is reversed. Nickel now goes into solution from the plate formerly the cathode, while spongy copper will largely be deposited on the erstwhile anode. The deposited copper falls off and collects in the bottom of the tank as a slime. It is found that the slime also carries iron and other formerly troublesome metallic impurities. A diaphragm may be used to prevent the slime contaminating the nickel deposit. With about ten alternations of current per minute, the reverse current being held for perhaps two seconds, a substantially copper-free nickel deposit may be obtained. (1,260,661; assigned to British American Nickel Corporation, Ltd.; Mar. 26, 1918.)

**Brick from Iron Blast Furnace Slag.**—J. B. SHAW of Alfred, N. Y., notes that while excellent paving brick is being made from English blast furnaces, an equivalent product has not yet been made in the United States. British practice consists in pouring molten slag into split metal molds, removing the red hot bricks when they have solidified sufficiently to be handled without deformation, and placing them into kilns where they cool and anneal slowly.

These bricks have a "stony" texture, while American bricks made in a similar manner are glassy and brittle. Composition of the slag probably has a great deal to do with these conditions, the British slag containing 26 per cent silica and 22 per cent alumina, while here the corresponding amounts are 34 and 14. In practice, American slags quickly solidify with a thin, tender skin, retaining a molten interior for a considerable period. To make successful brick the author specifies that the hot mass must be immersed in red hot sand, or some other hot medium which effectually excludes air and furnace gases, in such a manner that the heat from the packing and the molten interior reheats the chilled shell into a very viscous substance. Further cooling must now be arranged so that the exterior and interior of the mass shall cool at about the same rate, from 12 to 18 hours being required for proper annealing. (1,259,304; Mar. 12, 1918.)



## Synopsis of Recent Chemical and Metallurgical Literature

**Zirconium, its Alloys and Oxide.**—A paper followed by discussion on this rare element, especially its use as a refractory, was read at a meeting of the Birmingham (England) Metallurgical Society on March 14, 1918. Mr. LEOPOLD BRADFORD contributed the paper under discussion. It was remarked that the published material on zirconium and its compounds was so contradictory that it was difficult to know just what to believe. The metal has been recovered in amorphous, graphitic and crystalline form. The amorphous material, 97 per cent pure, produced by reducing potassium zirconio-fluoride with sodium in the presence of sodium chloride in a bomb furnace might be converted into metal 99.8 per cent pure by forming it into electrodes and striking an arc in an atmosphere of hydrogen at reduced pressure. The metal resembled white cast iron, had a specific gravity of 6.4, a specific heat of 0.0804, and a melting point of 1530 deg. C. Amorphous zirconium is a bad electrical conductor and oxidizes readily, while the crystalline variety oxidizes only at white heat and is not affected by strong acids. Aluminium-zirconium alloys are easily produced and have about the same properties as aluminium-titanium alloys. Ferro-zirconium is easily produced by the thermit process, and alloys containing up to 35 per cent had been used to some extent as scavengers. Alloys containing as high as 90 per cent have been marketed in America. It is rumored that such material is used in Germany for making armor some three times as resistant to penetration as the ordinary armor-plate, but the production of such ferro-alloys in quantity by the electric furnace was not thought to be commercially feasible. A self-hardening tool steel consisting of nickel, cobalt and chromium together with from 2 to 40 per cent of zirconium has been proposed.

The oxide, zirconia, was by far the most important compound, however, and has been largely used as a refractory. The properties of the material used in this way has been fully treated by H. C. MEYER in METALLURGICAL AND CHEMICAL ENGINEERING, Vol. 12, p. 791 and Vol. 13, p. 263. Dr. WALTER ROSENHAIN found that rather impure zirconia (75 per cent) had a very considerable shrinkage, apparently increasing with the temperature, and therefore making it imperative that the refractory should be burnt at a higher temperature than it was to resist during use. The refractory properties were increased enormously on purification, however. Though pure zirconia alone when molded for the production of refractory articles such as crucibles were apt to crack and crumble, even though heated up gradually, these drawbacks could be overcome by fusing the oxide in the electric arc furnace. Fused zirconia had a high thermal endurance, and was not affected when heated to redness and plunged into cold water, as its co-efficient of expansion—0.00000084—was extremely low, near to that of quartz glass. Its resistance to crushing stress was many times greater than that of quartz glass. Fused zirconia, therefore, appeared to be a refractory of exceptional value. Its hardness was between that of corundum and that of quartz. It had a specific

gravity of 5.89 and a porosity below 1 per cent. The melting point, as determined by PODSZUS, was 2,950 deg. C., but 0.5 per cent impurity reduced this by 100 deg.

**Electrolysis of Lock Valves at Panama.**—R. H. WHITEHEAD describes the corrosion taking place in the valves in the Panama Canal locks in the *Engineering News-Record*, June 27, 1918, V. 80, p. 1219. Fig. 1 shows the details of the valve chambers which have been giving the trouble. The valves control the flow of water in the 18-ft. culverts in the lock walls, and stop an opening 8 ft. wide by 18 ft. deep. During operation they are immersed in water more or less salty, although sea water is not necessary to set up the corrosive effects noted. It was thought that the valves would be replaced at intervals of ten years and that such replacement would be cheaper than to maintain protective coatings, but examination of several sets after less than two years' service shows very serious corrosion. Various metals are used in the construction—lead, babbitt, bronze, brass, steel and iron—of which steel is the most

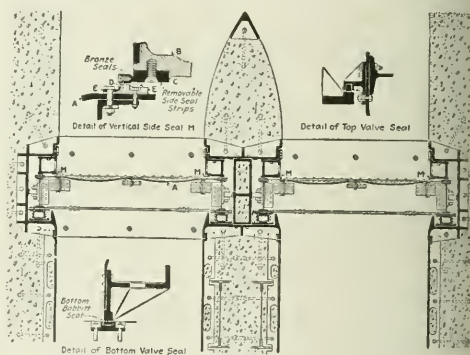


FIG. 1.—DETAILS OF VALVE CHAMBER

electro-positive, with iron next in the list. The only attempt to nullify the galvanic action in the original installation was the placing of nine zinc electrodes in the lowest valves. Various paints and protective coatings were tested by coating a steel bar, immersing it in salt water with a dissimilar metal, and noting the curve traced with a recording millivoltmeter. None of the coatings showed a protection for longer than ten days except "bitumastic," which was accepted for the work. The bottom babbitt seat on which the valve rested had caused so much corrosion that it was necessary to plane off the bottom of the valve, and the babbitt was replaced with greenheart. The removable side steel strips had been so badly corroded that the leakage had increased to nine times normal; therefore they were replaced with lignum vitae. The lead used in caulking fixed irons and leading-in bolts was replaced by cement, zinc electrodes placed at the bottom of the bronze seals and all parts except rubbing surfaces coated with "bitumastic." Pipes were led to the bottom of the roller trains at the side of the valves, through which crude oil will be forced. This oil is expected to adhere to the uncoated rubbing-parts as it rises through the water, thus protecting them from corrosion. The roller train rods and valve stems which pass through water-tight stuffing boxes of brass are corroding at a rate which will require renewal in three years.

**Corindite, a New Refractory.**—ALEXANDRE BIGOT, Engineer to the French Ministry of Armaments, described a new aluminous refractory at the meeting of the British Ceramic Society held May 14, 1918. The material used in its manufacture is either the white, high silica bauxite, or the red, high iron bauxite so common in the south of France. The method of burning the material has been patented by the late M. Noel Leceesne, and consists in heating a mixture of bauxite and anthracite in a cupola using forced draft. During the process a considerable portion of the aluminium is reduced to the carbide, but this is reoxidized by the oxygen in the blast to alumina. At the end of the heat there remains a vesicular block fused in successive layers, containing a large number of small alumina crystals. After removal of magnetic metallics, this so-called "corindite" has the following analysis:

|                  | White bauxite fused. | Red bauxite fused. | Naxos emery. |
|------------------|----------------------|--------------------|--------------|
| Alumina          | 68.80                | 69.25              | 69.46        |
| Titanic oxide    | 3.85                 | 3.70               | ...          |
| Silica           | 21.40                | 3.00               | 2.41         |
| Iron oxide       | 5.25                 | 23.35              | 19.03        |
| Carbon           | 0.60                 | 0.50               | ...          |
| Lime             | ...                  | ...                | 2.18         |
| Loss on ignition | 0.10                 | 0.15               | ...          |
| Combined water   | ...                  | ...                | 5.47         |

Corindite cones start to melt at 1950 deg. C., being more refractory than the original bauxite. This is because most of the original ferrous iron has combined to form spinels,  $Al_2O_3 \cdot FeO$ . Binders containing lime and magnesia must be avoided, bauxite and kaolin being preferred. Hand made bricks contract 2 per cent in drying; machine made bricks dry with constant volume. During the normal burning to 1400 deg. C. there is no apparent shrinkage. Between 1700 and 1735 deg. C. bricks expand about 0.5 per cent, and from that point to 1850 they contract 3 per cent. These brick resist wear from three to four times as well as the best magnesite bricks, and a lining in a cement kiln lasts twice as long as one made from unfused bauxite. Corindite is attacked by slag and scoria in the same way as bauxite brick.

**The Swiss Kiln for Deadburning Magnesite.**—Two Swiss engineers, STEIGER and FREY, have erected a continuous vertical kiln for the dead-burning of magnesite on the island of Euboea, Greece, which has been in successful operation eighteen months. The output of the natural-draft kiln which the new kiln was designed to supplant was 4 tons of calcined material per day. The new kiln averages 14 tons per day, with a fuel consumption of 20 per cent, as compared to 35 per cent for the old. The new kiln requires 30 horsepower for driving the moving parts. It consists of a vertical chamber, lined with magnesite brick. Magnesite rock is automatically elevated to the top and charged continually through a bell. It gradually descends against hot gases, passing through the hottest zone, and thence into the cooling zone. The bottom of the shaft is closed by a flat conical casting, ribbed on top. Rotation of this casting at the rate of about two per hour delivers the finished material to the discharge chute and tends to break any lumps formed in the burning. Heating is effected by artificial gas delivered hot from a producer alongside and burned in air delivered under pressure. A temperature of 1700 deg. C. (approx-

imately that of the open hearth furnace) is effected when using a good grade of coal. The gases are drawn from the top by a suction fan, leaving the furnace at about 150 deg. C. The designer, E. Steiger, who described the installation at the May meeting of the British Ceramic Society, believes that its fuel economy may commend it to those who are calcining and burning various materials in the less efficient rotary kiln.

**Ray Materials for Silica Products.**—*The Iron and Coal Trades Review* for May 17, 1918, contains an article by A. BIGOT, Consulting Engineer to the French Ministry of Armaments and Munitions, on the raw materials entering into the manufacture of silica refractories. The author recommends close analytical studies of the quartzites used. He finds that a natural rock analyzing 95.95 per cent  $SiO_2$ , 2.65 per cent  $Al_2O_3$ , and 1.96 per cent  $FeO$  shows under the microscope that the quartz crystals were surrounded with amorphous matter. On very fine grinding (through 200 mesh) and water classification, the lighter fraction was found on analysis to have an alumina content of 7.6 per cent, which corresponds to a clay content of 22 per cent. This finest material is rather plastic, and is more fusible than the original rock. The grinding of such a quartzite would set free the entrapped clay, which in the presence of the fine quartz particles and a small amount of lime forms a plastic mass which begins to vitrify and contract at 1250 deg. C., enveloping the quartzite grains and forming the correct bond. Therefore, a study of the natural binding material contained in massive quartzites should be completed to obtain intelligent bonding.

A most important physical test consists in taking a piece of the quartzite weighing about 100 grams, heating it gradually to 1710 deg. C., holding it at that temperature for one hour, and cooling in the furnace. During this time the rock has reached its maximum expansion, and the appearance after the test gives much information. Rocks containing alkalis or an excess of alumina are fused, and are therefore unsuitable for use as a silicious refractory. Some remain compact, preserve their shape, but present a few cracks, or in other cases split into a number of fairly large pieces. If the pieces themselves are tough and compact and of moderate size they are suitable for use in refractories. If the rock breaks into very small pieces, or granulate as do certain sandstones, the friability of the grains renders them unfit for use. Many sandstones act perfectly until a temperature of 1600 deg. C. is passed, rapidly disintegrating at 1700 deg. Flints usually break into large, tough pieces, which would seem to be ideal for the manufacture of bricks, but as a matter of fact, they contain so little natural clayey bond as to give unsatisfactory results. The author believes that the perfection of microscopic technology will soon enable one to determine the cause of the variable expansion of similar quartzites, ranging from 9 to 15 per cent. Exposure to high temperature changes quartz into cristobalite and into tridymite, with increase in volume. At the same time, the crystals are traversed by microscopic cracks, the number and size of which may determine the total expansion of the rock.

## Quantitative Determination of Suspended Tarry Matter in Gas

By F. W. STEERE

THE problem of making quantitative determinations of the suspended matter carried by coal retort gases has in the past given no end of trouble. The writer has tried every scheme suggested in technical papers, but found them not sufficiently reliable or too complicated for practical use.

The problem was solved for our own work by developing a suggestion found in the 1909 "Wrinkles" of the American Gas Institute. The method was worked

has been drawn. The tar carried by the gas leaves a characteristic stain on the paper and the amount of it can be determined either by comparison with a standard paper, or much more accurately, by weighing the paper before and after taking the picture.

The construction of the tar camera is well shown in the illustration, Fig. 1. It is made entirely of aluminium—including the cock. Aluminium will not corrode or be affected by any of the constituents of the gas.

Where the gas is under pressure, it is only necessary to screw the tar camera into the pipe line or apparatus at the point to be tested. The outlet of the camera is connected to the test meter, or measuring bottles, with rubber tubing, Fig. 2.

When the gas is under vacuum, it is usually simplest to use aspirators. If standard aspirator bottles of one or one-half cu.ft. capacity are used, the test meter is not necessary as the gas is measured as it is drawn into the aspirator. These aspirator bottles can be used in place of the test meter for measuring the gas when it is under pressure, as is illustrated in Fig. 3.

In long series of tests where a great number of pictures are to be taken with the gas under vacuum, the best arrangement is to connect the tar camera through a test meter and then tap into a point in the system

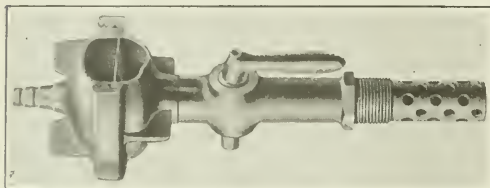


FIG. 1. VIEW OF TAR CAMERA SHOWING TEST PAPER ENCLOSED BETWEEN CASSETS.

out for determining the quantity of tar carried by coal gas at the different stages of condensation, but has also been found equally valuable for determining the quantity of suspended matter carried by any gas or the atmosphere. We have called the apparatus a tar camera because of the colored stain left on the filter paper by the tar taken from the sample of the coal gas under test. The tar camera does not eliminate gas plant trouble, but it does furnish a simple means of detecting it and studying its causes. How much tar does your gas carry on entering the ammonia scrubber? How much tar does it carry into the purifier? How do you know whether your tar extractor is working up to standard? As vital as these questions are—the number of plants that regularly make these determinations is almost negligible.

In plants subject to naphthalene trouble, it is especially important that a close watch be kept on the quantity of light tars carried into the ammonia scrubber. These tars are saturated with naphthalene when they enter the ammonia scrubber and come in contact with the ammoniacal scrubbing liquor. Phenols are dissolved out of the tar by the ammonia, forming salts more soluble in water than the phenols. The phenols are very good solvents of naphthalene. The inevitable result, therefore, when phenols are dissolved out of the tar, is to supersaturate the gas with the naphthalene set free.

This is the reason that gas tested after the ammonia scrubber shows more naphthalene than the gas entering the scrubber. The answer is to keep the quantity of tar carried by the gas at this point—a minimum. As a further illustration of the many problems that may be studied by the tar camera, consider the increased life of the purifying sponge if it were not fouled with light tars.

### THE TAR CAMERA AND ITS APPLICATION

The tar camera is so called because it is used to take "tar pictures"—a tar picture being a piece of special white paper through which a certain amount of gas



FIG. 2. TAR CAMERA ATTACHED IN CIRCUIT WITH METER

which is under a greater vacuum than that being tested. In this way, pictures can be taken very rapidly and accurately.

The following points must be observed to insure accuracy:

Run trial pictures to determine the number of papers necessary—See paragraph "Number of Test Papers" below.

Blow out the connections after each test. If



naphthalene crystals appear on the paper, swab out the connections between each test.

The connection between the tar camera and the apparatus must be as short as possible, otherwise tar

several papers, in general, 70 per cent will be retained by the first paper, 25 per cent by the second, 3 per cent by the third, and 2 per cent by the fourth. But this is not, by any means, a hard and fast rule.

#### COLORIMETRIC METHOD OF ESTIMATING TAR CARRIED BY GAS

We have found that there is a rough relation with a given type of gas between the shade of tar stain and its weight. It is therefore possible to approximate the quantity of tar in the gas by comparing the stain with a standard.

Such a method depends largely on the observer's skill and ability in comparing the color shades. This method is not reliable when the amount of tar is so great that the paper no longer shows through. This condition is reached when a 1-cu.ft. sample contains about 50 milligrams of tar (equivalent to 110 lb. per million cubic feet).

If the amount of tar in the gas exceeds 100 lb. per million, then it is best to take a small sample of  $\frac{1}{2}$  cu.ft. or  $\frac{3}{4}$  cu.ft. for comparison. Also it is difficult to estimate extremely small amounts of tar by this method, except by taking larger samples (10 cu.ft.). Two milligrams of tar in a 1-cu.ft. sample (4.4 lb. per million) will leave a very light stain on the paper.

It must be remembered that retort gas, water gas and producer gas all give different stains, and the shade of the stain from any kind of gas will be largely influenced by the amount of free carbon it carries. Retort gas usually gives a light brown stain, turning darker after exposure to the air. Producer gas usually runs darker. Water gas tar may be very light on account of the presence of carburetting oil. Therefore the density



FIG. 3. TAR CAMERA IN CIRCUIT WITH ASPIRATOR

will be deposited in the connections and the results will be incorrect.

Always fully open the cock below the camera. If the gas is "wiredrawn" at this point, tar will be deposited after the cock and the test paper will not show the correct amount.

If the gas pressure is so great that the test papers burst on opening the cock full, then it will be necessary to place a small cock in the hose line leading to the test meter to limit the rate of flow. Always pinch the rubber tubing after the tar camera while the cock is being opened, then let the flow gradually increase.

The proper amount of gas to be used in a test is either one cubic foot or ten cubic feet. For very tarry gas (foul main, etc.) it may not be possible to get one cubic foot through the paper. Stop the test and read the meter when the flow has nearly stopped. For very clean gas (after purifiers, etc.) a better idea of the quantity of tar in the gas can be had by running a larger sample, but it is seldom necessary to run more than ten cubic feet.

#### NUMBER OF TEST PAPERS TO BE USED IN A TEST

Tar in a finely divided state will not all be stopped by the first paper, but will go on through and stain the next one and sometimes four or five layers. Two is the number usually used for routine work, but where the papers are to be weighed to determine accurately the amount of tar, not less than four should be used. Tests show that when the tar is light and penetrates

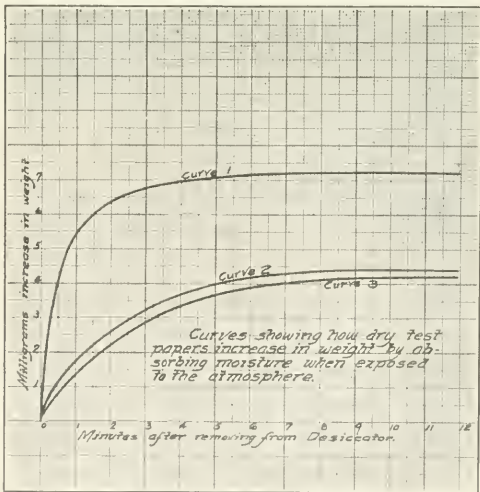


FIG. 4. RATE OF ABSORPTION OF MOISTURE BY PAPER

of the picture must be given consideration as well as the shade.

The amount of tar that is carried by gas will vary from about 800 lb. per million cu.ft. (5.6 grains per cu.ft.) or (262.4 milligrams per cu.ft.) down to clean

gas. We prefer to report tar in lb. per million cu.ft. This can be readily reduced to gallons per ton of coal.

Tar weighs approximately  $8\frac{1}{2}$  lb. per gallon. Retort gas runs approximately 10,000 cu.ft. per ton of coal carbonized. Producer gas runs approximately 120,000 cu.ft. per ton of coal. The weight of tar on a test paper is best reported in milligrams. If the tar in a 1-cu.ft. sample weighs 1 milligram, this is equivalent to 2.2 lb. per million cu.ft.

The colorimetric tests are not designed for accurate quantitative results—their value is rather roughly comparative. They will show any appreciable increase or decrease in the quantity of tar vapor present. They also indicate relatively the quality of the tar—which

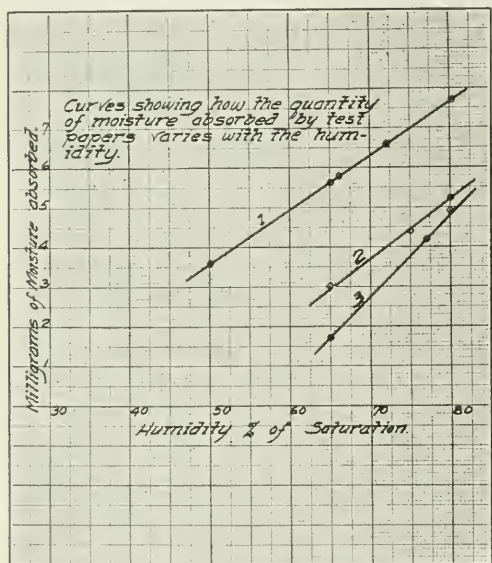


FIG. 5. VARIATION OF MOISTURE WITH HUMIDITY

is an index to the retort house, producer, or generator operation. If an accurate quantitative determination is required, it can be made as described below.

#### GRAVIMETRIC DETERMINATION AND CORRECTIONS

For weighing test papers, nothing but a good chemical balance can be used. A 3-inch filter paper commonly weighs about 280 milligrams (0.01 oz.) and the tar collected on it often weighs as little as 1 milligram (0.000035 oz.), or even less. Even if a suitable balance is available, the correct weighing of a test paper is not by any means a simple procedure.

A dry 3-inch filter paper will absorb as much as 7 milligrams of moisture from the atmosphere. The amount of moisture absorbed depends upon the humidity of the air, and somewhat on the temperature. It will not absorb as much moisture after being saturated with tar as it will when clean, and therefore the error due to moisture cannot be corrected readily.

To show the great difficulty of getting the correct weight of a test paper, we give below several curves showing the gain in weight of a test paper taken from a dessicator and placed on the pan of the balance.

Fig. 4 shows a set of curves giving the rate of absorption of moisture by paper at 85 deg. F.; 77 per cent humidity. Curve 1 is for a clean paper 3 inches in diameter, weighing 260 milligrams when dry and clean. Curve 2 is for a 3-inch paper weighing 280 milligrams when dry, but loaded with 8 milligrams of tar. Curve 3 is for a 3-inch paper weighing 289 milligrams when dry, but loaded with 59 milligrams of tar. It will be seen that the clean paper increased  $5\frac{1}{2}$  milligrams during the first minute it was on the scale. Even if the weighing could be accomplished in  $\frac{1}{2}$  minute, this would mean an error amounting to 6 lb. of tar per million cubic feet—entirely too much to neglect.

The curve shows that in 8 to 10 minutes the weights become steady, but, unfortunately, the curves for the clean and tar-covered papers are not alike.

The curves in Fig. 5 shows how the weights are affected by humidity. Curve 1 is for the clean paper mentioned above. Curve 2 is for the paper treated with 8 milligrams of tar. Curve 3 is for the paper saturated with 59 milligrams of tar.

These curves show that the weight of a 3-inch paper changes about 1 milligram for each 7.3 per cent change in the humidity. As the humidity is likely to vary from 50 per cent up to 75 per cent during a single day, it will be seen how hopeless it would be to try to weigh test papers under atmospheric conditions.

The only accurate method of getting the correct weight is to do the weighing in a perfectly dry atmosphere. Drying out the interior of the balance case (with pans of calcium chloride) does not reduce the humidity much below 50 per cent and opening the door to put in a test paper or change weights, alters the humidity at once.

We have therefore found it necessary to provide other means of weighing test papers in a perfectly dry atmosphere, and experience has shown that this eliminates both of these errors and makes possible a very accurate result.

The Steere Engineering Co. is prepared to furnish tar cameras and test papers weighed according to its special methods. The weighed papers are put up in packages of 12 each, with the weight of each paper marked on the envelope. After taking the tar samples, the papers may be returned to it for accurate reweighing.

#### MECHANICAL AND ELECTROSTATIC DETARRING PROCESSES

The problem of completely separating the condensed tar vapors from coal gas has probably received more study and met with less success than any other step in the manufacture of artificial gas. All public utility gas plant operators are familiar with the "P. & A." tar extractor in its many modifications. Extractors working on the principle of the submersion washer are also very numerous. These types of apparatus, although a long way from being perfect, will, when properly operated, clean retort gas and carburetted water gas sufficiently for commercial operation.

On producer gas, however, these types of apparatus are entirely inadequate. The detarring of producer gas requires much more strenuous treatment. This fact is clearly proven in that the efforts of the past twenty-five years have brought on the market detarring apparatus of an entirely different type than that used

by retort gas plants. Producer gas detarring apparatus may be roughly divided into two classes—apparatus based on compression, wire drawing and sudden expansion, and apparatus of the rotary type, into which water is sprayed. None of these devices have proved satisfactory, and the power and maintenance charges make them almost prohibitive. It is evident to both operators and experimenters that these methods of attack are wrong.

Contrasted with these mechanical methods of tar extraction, we have approached the problem from an entirely new angle. The Steere electrical detarring process<sup>1</sup> consists in simply passing the gas through a zone of high-tension alternating current. The high-tension discharges completely precipitate all of the condensed tar vapor.

The great advantages of the electrical process are in its extreme simplicity and complete effectiveness. The power cost is practically negligible. This process also opens up a great many possibilities in the manufacture of coal gas which, with the old methods of condensation and detarring, do not exist.

Detroit, Mich.

## Pyrotechnic Smoke Signals

The Inventions Board, General Staff, Army War College, Washington, D. C., is desirous of receiving ideas and suggestions relative to the production of suitable material for smoke signals. The following information on the subject is given for the benefit of those who may wish to experiment along this line. Communications should be addressed to the Inventions Board as given above.

It is desired to secure, if possible, a suitable chemical substitute for red Saxony arsenic now used for the manufacture of yellow smoke signals. The characteristics of such a chemical are that it should produce the effect required, that it should be procurable in large quantities, and that it should be perfectly stable in combination with other chemicals, such as potassium chlorate. The effect desired is a rather deep orange yellow. There is no objection to the use of dyes should these give the effect required and be procurable in large quantities at a reasonable price.

A suitable formula for a red smoke signal is also a desideratum. The effect required is a pronounced and positive shade of red. As in the case of the yellow smoke signal, chemicals composing it should be readily procurable and should be stable. Since, however, the requirements for this signal are considerably smaller than for the yellow smoke signal a greater latitude may be allowed in selecting slightly less readily available and higher priced material for this signal.

The smoke signals outlined above are displayed from rockets, Very cartridges, Viven-Bessiere cartridges and 35 M/M cartridges. The rockets now used by our forces weigh about two pounds with an approximate length of eighteen inches. The V-B, Very cartridges and 35 M/M cartridges have an average length of about six inches with a diameter respectively of two inches, 25 M/M and 35 M/M. The V-B cartridges are thrown from the rifle grenade discharger, and the Very cartridges and 35 M/M cartridges from the 25 M/M signal pistols.

Should any person accredited by the Inventions Board become interested in the two pistols outlined above, this office would be very glad to give all the information in its possession.

It should be noted that "auramine" has already been tried as a dye for the yellow smoke signal and that "paratoner" has been used in the red smoke signal.

## Quicksilver Production in First Half of 1918

The production of quicksilver in the United States during the first half of 1918 was 17,576 flasks, according to F. L. Ransome, of the United States Geological Survey, Department of the Interior. The total production in 1917 was 35,954 flasks, and as one-half of this is 17,977 flasks, the quantity thus far produced this year falls short by 401 flasks of that which should have been produced if the output this year is to equal that of last. As quicksilver, if not absolutely essential to the conduct of war, is a metal for which it would be exceedingly difficult to find satisfactory substitutes in all of its uses, and as an output of 36,000 flasks would, it is estimated, be barely enough to meet the demands in this country in 1918, the shortage indicated by the returns for the first half of the year calls for energetic efforts by the producers, the consumers, and the Government to increase the supply of the metal and to curtail less essential uses. With the enlargement of our Army the demand for quicksilver is likely to be considerably greater in 1919 than in 1918, and the perfection of satisfactory detonators for high explosives that shall contain little or no mercury is one of the urgent problems of chemistry as applied to war.

The decline in production during the first half of 1918 was due chiefly to the shortage and the increased cost of labor and to the exhaustion or depletion of known ore bodies under the stimulus of high prices for the metal. The practice at some of the larger mines has been to devote nearly all energy to getting out ore and to postpone the underground exploration and development that are necessary to insure long-continued steady production. In the language of the miners, some of the mines have been "gutted," and considerable time will be needed to restore them to a condition of high productivity. On the other hand, the high price of quicksilver has not led as extensively as had been hoped to the reopening of old mines long idle, although there are some notable examples of this result, and, during the second half of the year, these reopened mines may make good the shortage. Quicksilver mining is full of uncertainties, and capitalists are slow to invest extensively in an undertaking whose future can be so little foreseen. There is opportunity here for patriotism to cast the deciding vote where the cold doctrine of chances might turn the investor to industries offering greater assurance of reward.

One of the notable achievements in the industry during the year has been the successful adaptation of the rotary cement kiln to quicksilver metallurgy. Eight of these furnaces are now or will soon be in operation in California, and they are expected to make an increase in production that may more than offset the falling off during the first half of the year.

<sup>1</sup>Proceedings of the American Gas Institute, 1914.



## Personal

MR. M. H. BARNES, formerly chemist for the Illinois Steel Co., Gary, Ind., is now division inspector for the Aluminum Company of America, Maryville, Tenn.

DR. W. M. BURTON has been elected president of the Standard Oil Co. of Indiana to succeed the late Lauren J. Drake. Dr. Burton was recently awarded the Walter Gibbs medal of the American Chemical Society in recognition of his original work in the chemistry of petroleum, and as the discoverer of the so-called Burton process for producing gasoline.

MR. NORMAN CARMICHAEL is serving as chairman of the United War Work Campaign at Phoenix, Arizona.

MR. W. W. COLEMAN and T. H. SYMINGTON have been appointed as special assistants to the Chief of Ordnance. Mr. Coleman will have charge of the production of cannon, carriages, and their appurtenances and accessories. Mr. Symington will have charge of artillery ammunition, metal components, but will have nothing to do with the loading plant operation.

MR. STUART CROASDALE announces the change of his business address to 730 Symes Building, Denver, Col., where he will continue his practice as consulting engineer in mining, metallurgy and industrial chemistry.

DR. RUDOLF GAHL has opened a consulting office in the First National Bank Building, Denver, Col., where he will continue to specialize in hydrometallurgy of copper ores, the design of new plants and the solution of operating problems in copper mills. Dr. Gahl was formerly connected with an Arizona copper company.

MR. H. C. PARMELEE, Editor of CHEMICAL AND METALLURGICAL ENGINEERING, has gone abroad on invitation of the British Government to visit England and France. He is one of a party of fifteen editors of business magazines who will be the guests of the British Government for about two months, returning to the United States late in December. The purpose of the trip is to facilitate the interchange of thought and opinion between the allied nations.

## Obituary

MR. EDWARD J. DITTUS, Denver, Col., died at his home Oct. 11, 1918, of pneumonia, following an attack of influenza. Mr. Dittus was a graduate of the Colorado School of Mines and for several years after his graduation was assistant in the department of metallurgy at Golden. Recently he had been employed on potash production at Alliance, Neb., where he was taken sick. He is survived by a wife and child.

DR. ERNEST G. GENOUD died on Oct. 12, 1918, of pneumonia following an attack of influenza. He was born Feb. 23, 1889, graduated from the Massachusetts Institute of Technology, 1908, studied at Charlottenburg and Berlin, achieving his doctorate Jan. 15, 1911. He addressed himself more particularly to processes of fermentation and to special researches in regard to yeasts and other micro-organisms. For several years he had been engaged in technological research in the laboratory of Arthur D. Little, Inc., Cambridge, Mass. An article by him on "The Use of Micro-Organisms in Chemical Industry" appeared in our issue of Oct. 15.

PROFESSOR F. P. TREADWELL of Zürich, Switzerland, died suddenly of heart disease on June 25, 1918. Professor Treadwell was born at Portsmouth, N. H., in 1857. In the early seventies he attended school at Heidelberg, and later was lecture assistant there from 1878 to 1881 under Bunsen. His subsequent professional service was in the Eidgenössische Polytechnicum in Zürich. His excellent textbooks on chemistry are widely used and his loss will be felt among chemists.

## Current Market Reports

### The Non-Ferrous Metal Market

**Tuesday, Oct. 22.**—Due to the control of the prices of metals by the War Industries Board, the market has generally reflected none of the varying political conditions due to peace talk and has great stability.

**Aluminum.**—The Government prices on ingots 98 to 99 per cent Al are \$660 a ton f.o.b. plant in 50-ton lots; \$662 down to 15-ton lots; and \$666 down to 1-ton lots, which prices will continue the remainder of the year. Prices per pound for small lots vary from 40c. to 45c.; sheet aluminum, 18 ga. and heavier, 42c.; powdered aluminum, 100 mesh, 70c.

**Antimony.**—There seems to be an overproduction of antimony and prices are tending to decline in spite of the closing down of the French North African mines. Small quantities range from 13½c. to 13¾c. per pound.

**Chrome.**—Western production is now in slight excess of demand. The nominal quotation for 40 per cent ore is \$140 per unit, while 50 per cent ore is bringing \$170.

**Copper.**—The price of \$520 per ton for car load lots and 27.3c. per pound for small quantities is expected to be continued for another period at the conference to be held on Oct. 25 in Washington.

|                                 |     |        |          |
|---------------------------------|-----|--------|----------|
| Copper sheets, hot rolled.....  | lb. | \$0.36 | —\$0.37½ |
| Copper sheets, cold rolled..... | lb. | .37    | — .38    |
| Copper bottoms.....             | lb. | .44    | — .45½   |
| Copper rods.....                | lb. | .36    | — .37    |
| Copper wire.....                | lb. | .29½   | — .30    |
| High brass wire.....            | lb. | .28½   | — .29    |
| High brass sheets.....          | lb. | .28    | — .28½   |
| High brass rods.....            | lb. | .26½   | — .28    |
| Low brass wire.....             | lb. | .32½   | — .34    |
| Low brass sheets.....           | lb. | .32½   | — .34    |
| Low brass rods.....             | lb. | .32½   | — .34    |
| Brazed brass tubing.....        | lb. | .35    | — .36    |
| Brazed bronze tubing.....       | lb. | .42½   | — .43    |
| Seamless copper tubing.....     | lb. | .41    | — .42    |
| Seamless brass tubing.....      | lb. | .45    | — .46    |
| Seamless bronze tubing.....     | lb. | .47½   | — .49    |
| Bronze (gold) powder.....       | lb. | 1.00   | — 1.75   |

**Lead.**—The lead market is limited by selling restrictions, the supply being allocated by the Lead Committee. In car load lots at East St. Louis, the price is \$155 per ton. In New York, all speculative and traders' lead has disappeared. The Lead Committee apportions lead at 8.05c. to legitimate consumers.

**Manganese.**—The scale prices on page 629 of CHEMICAL & METALLURGICAL ENGINEERING, June 15, prevail; the highest price per unit being \$1.35.

**Silver.**—The Government price of \$1.01½ is hoped to promote production.

**Tin.**—The Tin Committee of the American Iron and Steel Institute has not yet announced the official price on tin. No doubt an understanding will have to be had with the producers before a final statement can be made public and as they are all in distant foreign countries, considerable time will elapse in intercommunication. During the first two weeks of this month about 1700 tons were imported. The price is about 78c. per lb. and is expected to decline.

**Tungsten.**—The Western producers of scheelite are reluctant in offering at \$26 per unit. High grade wolframite is bringing \$25. Off-grade ores vary from \$20 to \$24.

**Zinc.**—Spelter is tending to decline slightly. East St. Louis is quoting \$173 per ton for October delivery and \$170 for November and December. New York spot is 8.85c. to 9c. per lb.; sheet zinc, 15c., and zinc dust (300 mesh), 16c. per lb. in 1600-lb. casks.

### OTHER METALS

|                |        |        |         |
|----------------|--------|--------|---------|
| Bismuth.....   | lb.    | \$3.50 | —\$3.65 |
| Cadmium.....   | lb.    | 1.50   | —       |
| Cobalt.....    | lb.    | 2.50   | — 3.50  |
| Magnesium..... | lb.    | 1.75   | — 2.10  |
| Mercury.....   | 75 lb. | 125.00 | —       |
| Mercury.....   | lb.    | 1.95   | —       |
| Nickel.....    | lb.    | .40    | — .43   |
| Tungsten.....  | lb.    | 34.00  | —       |
| Iridium.....   | oz.    | 175.00 | —       |
| Palladium..... | oz.    | 135.00 | —       |
| Platinum.....  | oz.    | 165.00 | —       |

### The Iron and Steel Market

While the actual reports are not available, production of pig iron during October is believed to have been at a slightly better rate than the greatly improved rate shown for September, while production of steel is believed to have been

at about the September rate. The actual tonnage will show an increase, on account of October having 27 working days against 25 for September. The epidemic of Spanish influenza has affected the working forces at many plants, while others have practically escaped. The highest percentage of idleness was shown at the Duquesne Steel Works, where for some time about 750 men, or about 15 per cent. of the regular working force of 5100 men, were off, chiefly on account of the epidemic. At the various plants affected production was curtailed to a much less extent than would have been expected from the number of men absent. At many plants inoculation has been general for both office and mill forces. Company physicians have great confidence in the serum used. It may be interesting to note that some steel works physicians insist that autopsies they have witnessed prove that what has been diagnosed as pneumonia accompanying Spanish influenza is something altogether different, the lungs being attacked by ulcers, and not by the formation of fibrine in the blood, as in true pneumonia.

#### WAR REQUIREMENTS

Practically coincident with the German peace drive, there has been an increased demand for steel in France, both from our Allies and from General Pershing direct. The rate of advance of the Allied arms, it appears, measures the volume of many classes of steel required, particularly railroad material. While the consumption of shells does not appear from news despatches at the front to be particularly large at this time, there is pressure for more shell steel, and this despite the fact that the forge shops appear to have run somewhat ahead of the machining operations.

New practices are being introduced as to the distribution of steel to shipyards, the object being to insure a larger supply of the descriptions of steel most needed by certain yards without increasing the total production of ship steel. All comparisons that can be made from information generally available indicate that much more steel has been shipped for account of shipbuilding than has actually appeared in hulls. A reservoir of steel between mills and shipways is very desirable, but the steel needs to be properly spread, an excess of steel at one yard being of no help to another yard that may be short.

The oil pipe line across Scotland, news of which became public through an interview of Franklin D. Roosevelt, assistant secretary of the Navy, was laid with pipe furnished by American mills several months ago, though there was no publication of the matter at the time. The order involved about 60 miles of 8-inch pipe, about 4000 net tons. The object of the line is to make it unnecessary for oil tankers to make the long and somewhat dangerous trip around Scotland. A much larger project is the 300-mile oil line of 12-inch pipe in Texas, orders for which have just been distributed to mills after a lengthy consideration of the subject. About 40,000 net tons is involved. The leading interest was allotted 175 miles, the remaining 125 miles being distributed to several independents.

#### DISTRIBUTION REGULATIONS

Important rulings have been made as to "reflected priority," a matter that had been differently interpreted in various quarters in the trade. The regulations providing "automatic priority" were promulgated late in July, under date of July 1. Orders for various named purposes are given their respective grades of priority. Material for building vessels for the Fleet Corporation, for instance, is given A-5 priority. The shipyards, therefore, can attach A-5 priority to the orders they give for material. The question was whether those from whom they bought could in turn attach A-5 priority to the orders they gave, for material to be used in filling the shipyard's orders, and through how many links such a chain could extend. The general ruling is now made "priority can be reflected but once," whereas previously the view had been entertained and followed in some quarters that priority could continue through several links. For a concrete illustration, under former practice a rod mill might recognize as A-5 priority the order of a rivet maker engaged in supplying a shipyard, whereas under the new regulations the rivet maker

cannot secure automatic priority for his rods, but must apply for an individual priority. Fears are entertained that so many priority orders will now have to be secured as to delay their issuance, also that the mills will receive many small orders, instead of a few large orders, for rods, merchant mill products, etc., and have difficulty in making up convenient rolling schedules.

After long consideration of the subject of limiting the production of the smaller sizes of standard steel pipe, the War Industries Board has decided to curtail the output of butt weld pipe as a class, and has indicated to each pipe mill the tonnage of steel that can be used for butt weld pipe during November and December. The trade estimates that the regulation will reduce the output of butt weld pipe by about 30 per cent. Under normal conditions standard steel pipe is made from 3-inch downward in butt weld, while 2, 2½ and 3-inch sizes in oil country goods are made by the lap weld process. A part or all of the steel thus saved will pass into oil country goods, stimulating their production, this being one of the objects sought by the new regulation.

The various agreements that have been made from time to time in the past few weeks between the Food Administration and the packers of nonperishable food products in tin cans, whereby certain sizes of packages have been eliminated and the packing of certain products has been curtailed, have been arranged into one comprehensive schedule and distributed to the tin plate mills. Up to date the manufacture of tin plate has been confined to the filling of Government orders and the supplying of tin plate to packers of food products. Indications are that arrangements will be made with a number of packers of products other than food whereby they will limit their operations and will thereupon be allowed to buy and use tin plate. By the order of September 6 the tin plate mills were required to operate during the last three months of the year at not over 70 per cent. of their rate in the last quarter of 1917, but under the regulations as to tin plate consumption the permitted consumption fell far short of absorbing a 70 per cent. production. The prospect now is that enough consumption will be permitted to furnish a market for nearly a 70 per cent. output.

#### The Chemical Market

**COAL TAR PRODUCTS:**—The position of most intermediates has undergone no material change; during the interval, however, in view of the fact that only a few of the items were subject to a pressing demand, stocks on the whole have not accumulated to such an extent that a surplus is on hand. This condition is due mainly to the toluol situation, which is no easier, and other normal causes that are prevailing. The demand for benzol has been sufficient to take the stock off the market, that has been in evidence for some time, and among the more important crudes, phenol is still in pronounced demand, both in the local market and for export purposes. Paranitriline has evolved to an easier position in the market, and para amidophenol is noticeably scarce, both the base and hydrochloride products.

**Phenol:**—The market rules very firm and a decided pressing demand has developed in the local market, though interest in the product for export purposes is still very pronounced. However trading in this direction is considerably curtailed through the difficulty in obtaining export licenses. Prices are subject to no material change, for either that which has been manufactured prior to August 20, or the more recent product.

**Benzol:**—The lack of buying interest that has been prevailing for some time in this market is no longer in evidence, and while trading is of no important volume, there is sufficient business passing at present to take the slack off the market. For material in tank cars, prices are subject to no change while in certain directions a fractional increase was noticed for material in drums.

**Dinitrochlorbenzol:**—Quotations generally received would indicate the position of this item is very firm. Stocks, however, are by no means liberal, though they are of sufficient quantity to take care of the current demand.

**Monochlorbenzol:**—The item is one of the intermediates which is more or less neglected, and cheap offerings fre-



quently appear on the market. Large factors, however, are not disposed to shade prices to force business.

**Benidine:**—There is no pronounced volume of business reported in the local market and the most noticeable buying interest is for export purposes. The base material and the sulphate are subject to no change in prices, throughout the market.

**Para Amidophenol:**—A number of factors in this line state they are sold up until the latter part of November. However, fair quantities of the material are available for immediate shipment in spite of the persistent demand for both the base and H. C. L. products. Prices in most directions have been advanced from 25c. to 50c.

**Paranitraniline:**—The stringent situation that has confronted the consuming trade for some time appears to be easing up, though stocks are not reported in liberal supply. During the past week some cheap offerings appeared on the market, and in a few directions prices have declined from 5c. to 10c.

**Paranitrotoluol:**—Users of this product at the moment are seemingly experiencing some difficulty in supplying their wants, owing to the fact that most manufacturers are in a sold up condition, and offerings of the material that appear in the resale market are sold at rather high prices.

**Benzoate of Soda:**—A peculiar situation continues to exist in this market; talk is rather bullish from most directions and the active trading in the item appears to be mainly between dealers, as there is apparently no pressure on the part of consumers in the market. Therefore it is difficult to actually determine the market situation of either the acid or the soda. A variation of prices is heard, with weak holders appearing frequently and playing havoc with the market.

**Aniline Oil:**—Some factors are completely sold up for a period, but from certain sources available stocks are fully in accordance with the consumption requirements. There is a very steady demand reported, but prices are quotably unchanged.

**H. Acid:**—Production is centered to a few hands, who report that they are all sold and the small lots that appear in the resale market seem to originate considerable interest. Manufacturers are apparently reticent about quoting on material for early future shipment. Quotations generally heard are virtually nominal, in the absence of real business.

**Saccharines:**—There are now many conflicting rumors with regard to the general situation of this market, but as near as it is possible to determine the condition, it is generally conceded in most quarters that its entire position is weakening from day to day. Sales that were consummated are closed at some low levels and offerings of the product are made at prices said to be very low.

**Dinitrophenol:**—Inquiry for this item has been very good, but material for immediate delivery is said to be scarce and quite difficult to locate, in the open market. Large factors of production are devoting their entire energies for government requirement and therefore there is no encouragement offered for civilian consumption. Offerings of the material, on contract, are subject to no change.

**Diethylaniline:**—The production of this material is not in such quantities so as to accumulate a surplus in stocks. While trading is not very strong, the volume of business passing is sufficient to keep the market scarce of spot material. Prices are quotably unchanged and remain at firm levels.

**HEAVY CHEMICALS:**—The prevailing conditions, such as peace talk, Spanish influenza and liberty loan drives, have apparently been the factors for the continued lull in the market during the past two weeks. Citric acid, which under normal conditions, is seldom of any particular interest, has developed the feature of the market during the week. Soda ash maintains a firm position and under the lack of interest that has continued for some time; in caustic soda some of the more important factors are closely observing the market, but feel that a weakening position is likely to develop. Calcium carbide is subject to a heavy call and sodium sulphide is in firm demand. There developed a fair call for silicate

of soda, but stocks of both the latter items are reported to be meager.

**Soda Ash:**—Dense material in the various packing is none too liberal in supply, though a strong demand is noted for western shipment. The position of the light product in barrels appears to be somewhat easier and offerings of single bags are in fairly good quantities. Trading during the past week was rather inactive and among the more important sales noted was several cars of single bag material at \$2.65 ex-warehouse and sales were consummated for barrel material \$3.20 ex-warehouse. Offerings at the close were somewhat easier and single bags were quoted at \$2.65 to \$2.70 ex-warehouse and ex-dock and in Painsville material was held at \$2.70 with some middle west shipments quoted at \$2.60. The double bag situation was more restricted in offerings and lots which appeared on the market were held at \$3.25 works. Barrel material was available in New York at \$3.20 and in Chicago quotations ranged from \$3.05 to \$3.10, while in St. Louis the same quotation was heard.

**Bleaching Powder:**—A very serious situation is confronting the consuming trade at the moment and quantities of this material are becoming more and more difficult to obtain. Some factors are quoting 6½c. and buyers of fresh goods are seemingly obliged to meet these prices to supply their pressing needs.

**Caustic Soda:**—The situation of this market is causing considerable comment and in spite of the unusually quiet conditions that have been prevailing, stocks were none too free and the undertone was rather firm up to the latter part of the week when shipments were in excess of the purchasing, and from all appearances the market has seemingly developed a somewhat weaker position. Prices at the close show a downward tendency from \$4.45 to \$4.40 ex-warehouse and from works quotations generally went from \$4.40 to \$4.35. The ground product maintained a firmer position with quotations from the more important factors, ranging from \$5.25 to \$5.50 ex-warehouse.

**Oxalic Acid:**—No unusual activity is noted at the moment, in this market. However trading is steady through routine channels and supplies are reported to be fully in accordance with the consuming requirements. Prices remain at the former firm levels ranging from 40c. to 45c. according to seller.

**Citric Acid:**—There is no question that this item featured the market with a steady and persistent demand throughout the week, due, it is reported, to the extensive use of the product in the present prevailing epidemic. The steady buying pressure has depleted stocks to a very noticeable extent, and prices therefore have advanced from 85c. to \$1.06 at the close, with buyers unable to cover at the latter figure in many instances.

**Magnesia Calcined:**—The light technical product is reported to be in rather scant supply and quotations from several directions are virtually nominal in the absence of firm offerings. However, where small lots of this particular grade are available, prices have been advanced from 70c. to 75c.

**Calcium Carbide:**—A very firm market is prevailing for this item, but spot stocks are in very limited quantities; lots which appear on the resale market are seemingly the only material available. Producers are not offering owing to their sold up condition and there is no encouragement offered when the situation of the product may be somewhat easier. There is a variation of prices prevailing, ranging from 17c. to 19½c. per pound, in drums crated for export.

**Bicarbonate of Soda:**—Prices are steadily soaring for this product which is apparently becoming more scarce from day to day. Occasional lots which appear on the market seemingly create considerable interest, and at the close sales were consummated at from 3½c. to 4c. per pound, which is regarded a high mark for the product.

**Bichromate of Soda:**—The position of this item in the market is gradually weakening and prices are steadily declining, fractionally, from day to day. Quotations at the latter end of the week ranged from 21½c. to 22c. per pound, though in some directions sales were made as low as 21c.



|                       |      |      |      |
|-----------------------|------|------|------|
| Pennsylvania          | bbl. | 4 00 | ..   |
| Corning, Ohio         | bbl. | 2 85 | ..   |
| Somerset, Ky.         | bbl. | 2 60 | ..   |
| Worster, Ohio         | bbl. | 2 68 | ..   |
| Indiana               | bbl. | 2 28 | ..   |
| Illino.               | bbl. | 2 42 | ..   |
| Oklahoma and Kansas   | bbl. | 2 25 | ..   |
| Caddo, La., light     | bbl. | 2 25 | ..   |
| Corseana, Tex., light | bbl. | 1 24 | ..   |
| California            | bbl. | 1 74 | 1 57 |
| Gulf Coast            | bbl. | 1 35 | ..   |
| Mexican               | bbl. | 1 90 | ..   |
| Fuel Oil              |      |      |      |
| New York              | gal. | 15   | ..   |
| Philadelphia          | gal. | 10   | ..   |
| Baltimore             | gal. | 07   | 151  |
| Pittsburgh.           | gal. | 07   | 10   |
| Texas                 | bbl. | 1 85 | 2 35 |
| Los Angeles           | bbl. | 1 65 | ..   |

## Candlin (W. Lesale)

|                      |      |     |   |     |
|----------------------|------|-----|---|-----|
| New York, motor      | gal. | 243 | — | —   |
| Gas machine          | gal. | 411 | — | —   |
| 72-76 degrees        | gal. | 331 | — | 394 |
| 70-72 degrees        | gal. | 32  | — | 373 |
| 67-70 degrees        | gal. | 303 | — | 363 |
| Pittsburgh, motor    | gal. | 251 | — | —   |
| Chicago, motor       | gal. | 221 | — | 23  |
| Oklahoma, motor      | gal. | 211 | — | —   |
| San Francisco, motor | gal. | 201 | — | —   |

## Paraffine Waxes

|                             |     |      |   |      |
|-----------------------------|-----|------|---|------|
| Crude, 103 to 105 deg. m.pt | lb. | .081 | — | .09  |
| Crude, 118 to 120 deg. m.pt | lb. | .091 | — | .10  |
| Crude, 124 to 126 deg. m.pt | lb. | .10  | — | —    |
| Refined, 120 deg. m.pt      | lb. | .131 | — | —    |
| Refined, 128 deg. m.pt      | lb. | .14  | — | —    |
| Refined, 135 deg. m.pt      | lb. | .16  | — | .161 |
| Ozokerite, brown            | lb. | .75  | — | .80  |
| Ozokerite, green            | lb. | .85  | — | .90  |

## Lubricants

|                                             |      |     |   |     |
|---------------------------------------------|------|-----|---|-----|
| Black, reduced, 29 gravity, 25-30 cold test | gal. | 24  | — | 25  |
| Cylinder, light                             | gal. | .45 | — | .50 |
| Cylinder, dark                              | gal. | .39 | — | .43 |
| Paraffine, high viscosity                   | gal. | .40 | — | .41 |
| Paraffine, 0.903 sp. gr.                    | gal. | .36 | — | .38 |
| Paraffine, 0.885 sp. gr.                    | gal. | .26 | — | .28 |

## Flotation Oils

(Prices at New York unless otherwise stated)

|                                                                     |      |     |   |     |
|---------------------------------------------------------------------|------|-----|---|-----|
| Pine oil, crude, f. o. h. Florida                                   | gal. | 44  | — | —   |
| Pine oil, steam-distilled, sp. gr. 0.925-0.940                      | gal. | .58 | — | .60 |
| Pine oil, destructively distilled                                   | gal. | .58 | — | .60 |
| Pine-tar oil, sp. gr. 1.02-1.035                                    | gal. | .35 | — | —   |
| Pine-tar oil, double refined, sp. gr. 0.965-0.990                   | gal. | .42 | — | —   |
| Pine-tar oil, ref., light, sp. gr. 0.950, tank cars, f. o. h. works | gal. | .37 | — | —   |
| Pine-tar oil, ref., heavy, sp. gr. 1.025, tank cars, f. o. h. works | gal. | .28 | — | —   |
| Pine-tar oil, ref., thin, sp. gr. 1.060-1.080                       | gal. | .32 | — | —   |
| Turpentine, crude, sp. gr. 0.870-0.900                              | gal. | .45 | — | —   |
| Hardwood oil, f. o. h. Michigan, sp. gr. 0.960-0.990                | gal. | .23 | — | —   |
| Hardwood oil, f. o. h. Michigan, sp. gr. 1.06-1.08                  | gal. | .23 | — | —   |
| Wood-cresote, ref., f. o. h. Florida                                | gal. | .31 | — | —   |

## Naval Stores

|                                          |         |       |   |       |
|------------------------------------------|---------|-------|---|-------|
| Rosin A-E barrel                         | 280 lb. | 15.25 | — | 15.50 |
| Rosin F-I                                | 280 lb. | 15.50 | — | 16.00 |
| Rosin K-N                                | 280 lb. | 16.00 | — | 16.90 |
| Rosin W-G-W                              | 280 lb. | 16.90 | — | 17.25 |
| Spirits of turpentine                    | gal.    | .67   | — | —     |
| Wood turpentine, steam distilled         | gal.    | .63   | — | —     |
| Wood turpentine, destructively distilled | gal.    | .63   | — | —     |
| Pitch                                    | 200 lb. | 7.50  | — | —     |
| Tar, kila dried                          | 280 lb. | 13.00 | — | 13.50 |
| Retort tar                               | 280 lb. | 14.00 | — | 14.50 |
| Rosin oil, first run                     | gal.    | .80   | — | —     |
| Second run                               | gal.    | .83   | — | —     |
| Third run                                | gal.    | .88   | — | —     |
| Fourth run                               | gal.    | .98   | — | —     |

## Vegetable Oils

|                          |      |      |   |      |
|--------------------------|------|------|---|------|
| Castor oil               | lb.  | 34   | — | 38   |
| China wood oil           | lb.  | 30   | — | 31   |
| Cocoonut oil             | lb.  | .17  | — | .22  |
| Corn oil                 | lb.  | 18   | — | —    |
| Cottonseed oil, crude    | lb.  | 20   | — | 22   |
| Linseed oil, raw, ears   | gal. | 1.81 | — | 1.86 |
| Olive oil                | gal. | 4.25 | — | 4.50 |
| Peanut oil, crude        | lb.  | .18  | — | .22  |
| Soya bean oil, Manchuria | lb.  | .17  | — | .181 |

## Glues

|                            |      |      |   |      |
|----------------------------|------|------|---|------|
| Extra white                | lb.  | 36   | — | 45   |
| Cabinet                    | lb.  | 31   | — | 40   |
| Brown foot stock           | lb.  | 63   | — | 80   |
| Fish glue, 50-gal. barrels | gal. | 1.00 | — | 1.80 |

## Miscellaneous Materials

|                                     |         |       |   |       |
|-------------------------------------|---------|-------|---|-------|
| Barytes, floated, white, foreign    | ton     | 38.00 | — | 42.00 |
| Barytes, floated, white, domestic   | ton     | 35.00 | — | 36.00 |
| Beeswax, white, pure                | lb.     | .63   | — | .63   |
| Beeswax, unbleached                 | lb.     | .43   | — | .48   |
| Blau fix                            | lb.     | .051  | — | —     |
| Casie                               | lb.     | .071  | — | —     |
| Ceylon graphite                     | lb.     | .071  | — | —     |
| Chalk, light, precipitated, English | lb.     | .041  | — | .06   |
| China clay, imported, lump          | ton     | 20.00 | — | 40.00 |
| China clay, domestic, lump          | ton     | 15.00 | — | 22.50 |
| Feldspar                            | ton     | 8.00  | — | 12.00 |
| Fluorspar, gravel, f. o. h. mines   | ton     | 28.00 | — | 40.00 |
| Fluorspar, washed, powdered         | ton     | 90.00 | — | —     |
| Filler's earth, powdered            | 100 lb. | 1.50  | — | 2.00  |
| Japan wax                           | lb.     | 26    | — | 29    |
| Manganese graphite                  | ton     | 75.00 | — | —     |
| Madagascar graphite                 | lb.     | 10    | — | 15    |
| Shupe-shallae                       | lb.     | .72   | — | .80   |
| Pumice stone                        | lb.     | .04   | — | —     |
| Red lead, dry, carloads             | 100 lb. | .411  | — | .113  |
| Soapstone                           | ton     | 15.00 | — | 25.00 |
| Stearic acid, 120 deg. m.pt         | lb.     | 15    | — | 14    |
| Stearic acid, 140 deg. m.pt         | lb.     | 18    | — | 19    |
| Talc, American, white               | ton     | 20.00 | — | 40.00 |
| White lead, dry                     | lb.     | .091  | — | .101  |

## Refractories, Etc.

(F.O.B. Works)

|                                    |          |        |   |        |
|------------------------------------|----------|--------|---|--------|
| Chrome brick                       | net ton  | 175.00 | — | —      |
| Chrome cement                      | net ton  | 75.00  | — | —      |
| Clay brick, first quality fireclay | per 1000 | 50.00  | — | 55.00  |
| Clay brick, second quality         | per 1000 | 35.00  | — | 40.00  |
| Magnesite, raw                     | ton      | 30.00  | — | 35.00  |
| Magnesite, calcined, powdered      | ton      | 50.00  | — | 65.00  |
| Magnesite, dead burned             | net ton  | 50.00  | — | 60.00  |
| Magnesite brick, (24 x 12 x 2)     | net ton  | 110.00 | — | 125.00 |
| Silica brick                       | per 1000 | 50.00  | — | 60.00  |

## Ferroalloys

|                                                                              |     |        |   |        |
|------------------------------------------------------------------------------|-----|--------|---|--------|
| Ferrocobaltantimony, 15-18 per cent, carloads, f. o. b. Niagara Falls, N. Y. | ton | 200.00 | — | 250.00 |
| Ferrocromium                                                                 | ton | 15.00  | — | 30.00  |
| Ferrocromium, per lb. of Cr.                                                 | lb. | .30    | — | .40    |
| Ferromanganese, domestic, 70 per cent basis                                  | ton | 250.00 | — | —      |
| Ferromanganese, foreign                                                      | ton | 325.00 | — | —      |
| Spiegeleisen (16-18%)                                                        | ton | 75.00  | — | —      |
| Ferromolybdenum, per lb. of Mo.                                              | lb. | 3.50   | — | 4.50   |
| Ferrosilicon, 75 per cent, f. o. b. N. Y.                                    | ton | 153.00 | — | 160.00 |
| Ferrosilicon, 50 per cent, contract                                          | ton | 153.00 | — | 160.00 |
| Ferrotungsten, 75-85 per cent, f. o. b. Pittsburgh                           | lb. | 2.35   | — | 2.40   |
| Ferrouranium, f. o. b. works, per lb. of U.                                  | lb. | 7.50   | — | —      |
| Ferrovandium, f. o. b. works                                                 | lb. | —      | — | —      |

## Ores and Semi-finished Products

|                                                         |      |       |   |        |
|---------------------------------------------------------|------|-------|---|--------|
| Chrome ore, 45 per cent minimum, f. o. b. Cal. per unit | ton  | 1.50  | — | 1.55   |
| Chrome ore, 43 per cent and over, New York, per unit    | ton  | 1.40  | — | —      |
| Coke                                                    | ton  | 6.00  | — | 7.00   |
| Manganese ore, 48 per cent and over, per unit           | ton  | 1.20  | — | —      |
| Manganese ore, chemical                                 | ton  | 80.00 | — | 100.00 |
| Molybdenite, per lb. of MoS <sub>2</sub>                | lb.  | 1.25  | — | 1.50   |
| Tungsten, Scheelite, per unit of WO <sub>3</sub>        | ton  | 25.50 | — | —      |
| Tungsten, Wolframite, per unit of WO <sub>3</sub>       | ton  | 24.00 | — | —      |
| Uranium oxide, 96%                                      | lb.  | 3.25  | — | 3.60   |
| Vanadium pentoxide, 99%                                 | lb.  | 10.50 | — | —      |
| Pyrites, foreign                                        | unit | 17    | — | —      |
| Pyrites, domestic                                       | unit | 28    | — | 30.00  |

## Plant Supplies

## BUILDING MATERIALS

|                                           |         |        |   |        |
|-------------------------------------------|---------|--------|---|--------|
| Common clay bricks                        | M       | 13.00  | — | 14.00  |
| Yellow tile, 4 x 12 x 12                  | M       | 40.00  | — | —      |
| Hollow tile, 12 x 12 x 12                 | M       | 170.00 | — | —      |
| Lime                                      | ton     | 16.50  | — | —      |
| Portland cement                           | bbl.    | 2.59   | — | 27.00  |
| Single glass (8 1/2 lb.), 10 x 26-16 x 24 | ton     | 31.00  | — | 39.00  |
| Double glass (64 lb.), 10 x 26-16 x 29    | ton     | 31.00  | — | 39.00  |
| Yellow pine lumber                        | M       | 39.00  | — | 45.00  |
| Fir lumber                                | M       | 38.00  | — | 53.00  |
| Henlock                                   | M       | 24.50  | — | 40.00  |
| Tarred felt (14-lb. sq.)                  | ton     | 68.00  | — | —      |
| Roofing pitch                             | ton     | 27.00  | — | —      |
| Asphalt coated roofing (35-55-lb. sq.)    | sq.     | 1.60   | — | 2.45   |
| Slate surfaced asphalt shingles           | sq.     | 3.50   | — | 5.50   |
| Corrugated galvanized iron                | ton     | 109.00 | — | 127.00 |
| Putty                                     | 100 lb. | 6.25   | — | —      |
| Red oxide (Fpte. Copperas)                | 100 lb. | 15.00  | — | 20.00  |
| Native red oxide                          | 100 lb. | 3.25   | — | 8.00   |
| Red metallic paint                        | 100 lb. | 12.00  | — | 1.50   |
| White lead in oil                         | 100 lb. | 11.84  | — | 14.00  |
| Red lead in oil                           | 100 lb. | 12.28  | — | 14.50  |
| Zinc oxide (dry)                          | 100 lb. | 13.66  | — | 14.00  |
| Zinc oxide—leaded                         | 100 lb. | 9.00   | — | 10.00  |
| Yellow ochre                              | 100 lb. | 1.50   | — | 10.00  |
| Ultra marine blue                         | 100 lb. | 14.00  | — | 50.00  |
| Prussian blue                             | 100 lb. | 135.00 | — | 150.00 |
| Chrome green                              | 100 lb. | 127.00 | — | —      |
| Paris green                               | 100 lb. | 43.00  | — | 49.00  |
| Mineral black                             | 100 lb. | 1.75   | — | 2.25   |
| Powdered bone black                       | 100 lb. | 5.50   | — | 12.00  |
| Lampblack                                 | 100 lb. | 15.00  | — | 45.00  |
| Gas carbon                                | 100 lb. | 16.00  | — | 25.00  |
| Mexican petroleum pitch                   | 100 lb. | 1.00   | — | 2.00   |
| Gilsonite                                 | 100 lb. | 2.00   | — | 2.50   |
| Coal tar pitch                            | 100 lb. | .60    | — | 1.25   |

## STRUCTURAL IRON

|                                   |     |        |   |        |
|-----------------------------------|-----|--------|---|--------|
| Blue annealed sheet iron          | ton | 84.00  | — | 89.00  |
| Black sheet iron                  | ton | 96.00  | — | 104.00 |
| Galvanized iron                   | ton | 105.00 | — | 135.00 |
| Tern plate, 8-lb. coating         | ton | 150.00 | — | —      |
| Tern plate, 15-lb. coating        | ton | 175.00 | — | —      |
| Tern plate, 25-lb. coating        | ton | 200.00 | — | —      |
| Tern plate, 40-lb. coating        | ton | 240.00 | — | —      |
| Tin plate, prime                  | ton | 155.00 | — | —      |
| Tank plates                       | ton | 65.00  | — | 70.00  |
| Beams, channels, angles, T's, Z's | ton | 60.00  | — | 65.00  |
| Rivets                            | ton | 88.00  | — | 92.00  |
| Steel pipe, 1 to 3-inch           | ton | 51.00  | — | —      |
| Bar iron and steel                | ton | 60.00  | — | 70.00  |
| Chain (1 inch proof coil)         | ton | 150.00 | — | —      |
| Nails, bolts, nuts, washers       | ton | 70.00  | — | 80.00  |
| Tool steels, special alloys       | ton | 300.00 | — | 500.00 |
| Reinforcing pig iron              | ton | 36.00  | — | —      |
| Reinforcing steel                 | ton | 42.50  | — | —      |
| No. 2 foundry                     | ton | 32.00  | — | —      |
| Steel billets (4 x 4)             | ton | 47.50  | — | —      |

## POWER HOUSE SUPPLIES

|                               |     |      |   |      |
|-------------------------------|-----|------|---|------|
| Steam packing, rubber duck    | lb. | .90  | — | 1.10 |
| Asbestos, high pressure       | lb. | 1.76 | — | —    |
| Asbestos, wired               | lb. | 1.50 | — | —    |
| Asbestos, graphited braid     | lb. | 1.21 | — | —    |
| Asbestos, wick                | lb. | .75  | — | —    |
| Rubber, sheet                 | lb. | .60  | — | —    |
| Cup grease                    | lb. | .07  | — | —    |
| Transmission grease           | lb. | .07  | — | —    |
| Axle grease                   | lb. | .041 | — | —    |
| Gear grease                   | lb. | .07  | — | —    |
| Cotton waste                  | lb. | .081 | — | .13  |
| Hose, underwriters, 2 1/2 in. | ft. | .75  | — | —    |
| Hose, air, 1 in.              | ft. | .30  | — | .60  |

# INDUSTRIAL

Financial, Construction and Manufacturers' News

## Construction and Operation

### Alabama

**ASHLAND**—The Dixie Graphite Co., 407 Jefferson Bank Building will build a mill on its graphite property here having a capacity of 200 tons per day. J. R. Malaney, in charge.

**BIRMINGHAM**—The Welded Products Co., 303 American Trust Building, has awarded the contract for the construction of a 90 x 225 ft. acetylene welding plant to the Smallman-Brice Construction Co., American Trade Building.

### Arkansas

**FORT SMITH**—The Missouri-Arkansas Oxygen Co., c/o Best-Clymer Manufacturing Co., will install a hydrogen plant in connection with its proposed oxygen plant.

### California

**GIANT**—Construction Division of the War Department, Washington, D. C., has awarded the contract for the construction of a TNT plant located near the nitric acid plant of the Giant Powder Co., to Grant, Smith & Co., Henry Bldg., Seattle, Wash. Estimated cost, \$1,435,000.

**MANTECA**—The city will build a sewerage system, outfall sewer and disposal plant. Estimated cost, \$42,000.

### Colorado

**SILVER CLIFF**—The Buffalo Hunter M. M. & D. Co. will build a concentration, roasting and cyaniding plant at its Mn-Ag open pit mine having a capacity of 400,000 tons per year and is in the market for crushers, Wilfley tables, gas producers, tube mills, Dorr agitators, steam shovels, track cars, engines, boilers and pipe. Estimated cost, \$150,000. Captain L. D. Miller, superintendent.

### District of Columbia

**WASHINGTON**—Bids will be received at the office of the General Purchasing Officer, Panama Canal, until November 13 for furnishing ferro-manganese, carbon bisulphide, calcium chloride, wax, sulphuric acid, ethyl alcohol, pitch, glue, fire clay, graphite, enamel, white zinc, red oxide of mercury, shellac, etc.

### Florida

**MIAMI**—The Bureau of Yards & Docks, Navy Department, Washington, D. C., will receive bids until Nov. 4 for the construction of a reclaiming building and septic tank. Specification No. 3549. Estimated cost, \$20,000.

### Illinois

**FRANKFORT**—The Elgin, Joliet & Eastern Railway Co. has awarded the contract for the construction of a water softening plant here to William Graver, 4809 Todd Ave., Chicago. A. Montzheimer, Joliet, chief engineer.

**GREAT LAKES**—The Bureau of Supplies & Accounts, Navy Department, Washington, D. C., will alter and build additions to its sewage disposal plant. Estimated cost, \$13,000.

**MOUNT CARMEL**—A Lieberman and Lewis Dumes will build a fertilizer plant near here. Estimated cost, \$25,000.

**SPAUDLING**—The Elgin, Joliet & Eastern Railway has awarded the contract for the construction of a water softening plant here, to William Graver, 4809 Todd Ave., Chicago. A. Montzheimer, Joliet, chief engineer.

### Iowa

**FAIRPORT**—The Commissioner of Fisheries, Department of Commerce, Washington, D. C., will build a laboratory building at the biological station here.

### Kansas

**FORT SCOTT**—The city will build dam and filtration plant. Estimated cost, \$82,000. Black & Veatch, engineers Interstate Building, Kansas City, Mo., preparing plans.

**GALENA**—The City will build a filtration plant. Estimated cost, \$100,000. Burns & McDonnell, engineers, Interstate Building, Kansas City, Mo., preparing plans.

### Louisiana

**NEW ORLEANS**—The Jackson Brewing Co. will remodel and convert its building into a plant for dehydrating vegetables, etc., also the manufacturing of alcohol and syrup.

### Maryland

**INDIAN HEAD**—The Bureau of Yards & Docks, Navy Department, Wash., D. C., will build a laboratory building here. Specification No. 3203. Estimated cost, \$20,000.

**MONKTON**—The Monkton Roller Co., Inc., has awarded the contract for the construction of a roller mills plant, to E. H. Mosher, 427 Munsey Building, Baltimore. Project includes 32 x 72 ft. main mill, 20 x 45 ft. corn mill and hydro electric plant, also equipment for same. Estimated cost, \$134,000.

### Massachusetts

**LEE**—The Smith Paper Co. has awarded the contract for the erection of a three-story, 90 x 100 ft. concrete and brick paper mill addition, to the Lynch Brick Construction Co., 205 High St., Holyoke. Estimated cost, \$60,000.

**WORCESTER**—The Wyman-Gordon Co., 105 Madison St., has awarded the contract for the construction of an additional story to its laboratory on Gold St. to E. J. Cross Co., 82 Foster St.

### Michigan

**DETROIT**—The Cummings & Moore Graphite Co., 672 Water St., will build a three-story, 133 x 135 ft. grinding room addition. Stahl & Kinsey, 117 West Ford St., architect, taking bids.

**GRAND RAPIDS**—The Grand Rapids Brass Co. will build a three story addition to its plant at Scribner Ave. and Shawmut St. Osgood & Osgood, Engrs., preparing plans.

**MANISTIQUE**—The Manistique Pulp & Paper Co. will build an addition to its plant. Estimated cost, \$500,000. H. J. Storer, consulting engineer.

### Missouri

**CIETWOOD**—Pfaeffle & Kelley have awarded the contract for remodeling their 200-ton plant to Carmody V. McGee, 631 Frisco Building, Joplin, and is in the market for lumber, mill hardware, engine, sludge tables, roofing and air compressors. Estimated cost, \$50,000. J. P. Kelley, superintendent.

**JOPLIN**—The C. H. & M. Mining Co. will remodel and improve its plant and build tramway and is in the market for new scales, sludge tables, lumber, rails, waste ties, wire cables, scales and engine. Estimated cost, \$6000. Burt Pitts, superintendent.

**ST. LOUIS**—The Mallinckrodt Chemical Works, 2nd and Mallinckrodt St., has awarded the contract for the erection of a factory at 100 Salisbury St. for the manufacture of chemicals to the A. H. Haessler Building & Contracting Co., Wainwright Bldg. Estimated cost, \$6000.

**ST. LOUIS**—The Pan Electric Manufacturing Co., 735 South 4th St., will build laboratories in connection with its proposed two-story, 40 x 50 ft. concrete and brick office building at 4090 Binkham St. Estimated cost, \$10,000. G. P. West, Wainwright Building, architect.

**WEBB CITY**—The Brown-Head Mining Co., Miami, Okla. will rebuild the 500-ton mill it recently purchased. A. Rowe, general manager.

### New Jersey

**CLAREMONT**—The Standard Oil Co., 25 Broadway, New York City, N. Y., has awarded the contract for the construction of a tank house and a filter house here to James Stewart & Co., Church St., New York City, N. Y.

**ELIZABETHPORT**—The Borne-Schrymer Co. has awarded the contract for the construction of a two story, 30 x 50 ft. concrete chemical laboratory, also a four story, 42 x 62 ft. addition to the city house to H. D. Best Co., Flatiron Building, New York City, N. Y.

**JERSEY CITY**—The Baker Castor Oil Co., Washington St., will build a reinforced-concrete addition to its plant. Estimated cost, \$75,000.

**NEWARK**—The Oxweld Acetylene Co., 640 Frelinghuysen Ave., will build a three story, 42 x 100 ft. addition to its plant. Estimated cost, \$50,000.

**TRENTON**—The School of Industrial Arts, West State and Willow St., will build an automobile engine laboratory in connection with the proposed two story, 56 x 65 ft. school on Quarry St. Frank Frederick, director.

### New York

**ALBANY**—The Patent Vulcanite Roofing Co., Tivoli St., has awarded the contract for the erection of a one story, 72 x 245 ft. concrete and brick factory to the Hamill Construction Co., Gay Bldg., Troy. Estimated cost, \$30,000. Noted Oct. 15.

**BINGHAMTON**—The Binghamton State Hospital will build an addition to its analytical laboratory. L. F. Picher, Capitol, Albany, architect.

**BROOKLYN**—The New York Quinine & Chemical Co., 99 11th St., will build a 50 x 100 ft. concrete and brick addition to its factory on Berry St. Estimated cost, \$25,000. T. Englehardt, 905 Broadway, architect.

**LONG ISLAND (Laurel Hill)**—The General Chemical Co., 25 Grand St., New York City, has awarded the contract for the erection of a two story, 40 x 116 ft. concrete and brick factory at Hall St. and Washington Ave., Laurel Hill, to Ledy & Moore, 105 West 40th St., New York City. Estimated cost, \$35,000.

**TONAWANDA**—The Acheson Graphite Co., Buffalo Ave., Niagara Falls, has awarded the contract for the construction of a new plant to the J. W. Cowper Co., Fidelity Building, Buffalo. Estimated cost, \$15,000.

### North Carolina

**ROSMAN**—The Texaway Tanning Co. will reconstruct its mill recently destroyed by fire; new machinery will be installed in same.

**WILMINGTON**—The city will improve its water-works to include a reinforced concrete sedimentation basin having a capacity of 1,500,000 gallons, a 5,000,000 gallon centrifugal steam driven pump and four 15 ft. additional filter units, etc. J. Newton Johnson, city engineer, preparing plans.

### Ohio

**AKRON**—The Quick Rubber Co., Home Ave., will build a factory. Estimated cost, \$25,000. G. W. Reid, general manager.

**CLEVELAND**—The Cleveland Brass & Copper Mills Co., 322 Guardian Building, has awarded the contract for the construction of a one story, 77 x 130 ft. concrete, brick and steel factory on Rabbit Rd., to Craig Curless Co., Guardian Building. Estimated cost, \$50,000.

**LORAIN**—The Cleveland Salt Co., 5312 Central Ave., Cleveland, will build a chemical plant here, consisting of six buildings, one and two stories high. H. G. Finley, 503 Union Building, Cleveland, engineer.

**NORWOOD**—The city plans an election on November 5 to vote on a \$50,000 bond issue for the construction of a water softening system. Allen Klessinger, city engineer.

**PARMA** (Cleveland P. O.)—The Swift & Co., 3240 W. 15th St., will build a two story, 50 x 75 ft. concrete, brick and steel fertilizer factory. Estimated cost, \$25,000.

### Oklahoma

**CENTURY**—The Federal Lead and Zinc Mining Co. will build new incline hoister skids and remodel its 400-ton concentration plant. It is in the market for lumber, cross ties, concrete, chain, making machinery, ore cars, hoister, wiring, cables, belts, engine, pipe, roofing and track. Estimated cost, \$35,000. W. M. Martin, superintendent.

**GROVE**—W. T. Croslin and George F. Clark will build a kaolin plant and is in the market for engine, boiler, lumber, concrete, hardware, chain, making machinery, kiln, dryers, track, cars, belts, pumps and roofing. Estimated cost, \$25,000.



**STILLWATER**—The city will build a filter plant, boiler room, engine room, etc.; filtering equipment having a capacity of 850,000 gallons per hour will be installed in same. J. L. Moore, city clerk.

### Oregon

**BEAGLE**—The Rainier Quicksilver Co. will enlarge its plant and is in the market for furnace equipment for same. Estimated cost, \$5000. Samuel Bertleson, superintendent.

### Pennsylvania

**CLOYLAND**—The Construction Division of the War Department, Washington, D. C., has awarded the contract for the construction of a toxic gas plant to the Cleveland Construction Co., 1023 Citizens Building, Cleveland, Ohio. Estimated cost, \$2,000,000.

**EMPORIUM**—The Construction Division of the War Department, Washington, D. C., has awarded the contract for the construction of eight units for the manufacture of explosives, located near the plant of the Aetna Explosive Co., to the Leonard Construction Co., 332 South Michigan Ave., Chicago, Ill. Estimated cost, \$2,000,000.

**HEIDELBURG**—The Aetna Chemical Co. will rebuild its fusion building recently destroyed by fire.

**MOUNT UNION**—The Construction Division of the War Department, Washington, D. C., has awarded the contract for the construction of a plant here for the manufacture of explosives to the Leonard Construction Co., 332 South Michigan Ave., Chicago, Ill. Estimated cost, \$1,000,000.

**PHILADELPHIA**—Powers, Weightman & Rosenkrantz, 916 Broad St., has awarded the contract for the construction of a factory for the manufacture of chemicals to R. C. Ballinger, 17th and Arch Sts. Estimated cost, \$6000. Noted June 15.

**PHILADELPHIA**—The Tigra Steel and Iron Co., 52nd St. and Gray's Ave., will build a 24 x 60 ft. water softening plant for its gun plant here.

### Rhode Island

**EAST PROVIDENCE**—The Rumford Chemical Works, 231 South Main St., has awarded the contract for the construction of a 1-story, 50 x 92 ft. addition to its plant to William Merchant, Inc., 186 Weybosset St. Estimated cost, \$18,000.

### South Dakota

**PLATTE**—C. F. Slate, city auditor, will receive bids until November 4 for the construction of a sewerage system and sewage disposal plant involving approximately \$190 lin. ft. 15 in. and 1200 lin. ft. 12 in.; 1465 lin. ft. 10 in. and 26,075 lin. ft. 8 in. sewer, together with necessary appurtenances, septic tank, sludge bed and sand filter bed.

### Tennessee

**MEMPHIS**—The Memphis Gas & Electric Co. has awarded the contract for the construction of two concrete buildings and a suburban house and the installation of 27 ovens to Phillips Lang Co., 343 Dearborn St.

### Texas

**AUSTIN**—The city will receive bids until Oct. 31 for the construction of sewage disposal plant. A. P. Woolridge, mayor.

**HONEY GROVE**—The city will build a hypochlorite disinfecting plant. Address the Mayor.

### Virginia

**NORFOLK**—The Bureau of Yards & Docks, Navy Department, Washington, D. C., will build a galvanizing plant, oxyacetylene and gas welding plant here. Specification No. 3333. Estimated cost, \$10,000.

**OAK**—The Virginia Mari Co., Box 1594, Richmond, is in the market for complete equipment for a lime and fertilizer plant.

**PORTSMOUTH**—The City Gas Co. and the United States Housing Corporation will build a gas plant to furnish sufficient gas to the Government settlement at Paradise Creek and Villa Heights; plans include the installation of machinery, laying of pipe, etc. Total estimated cost, \$175,000 to \$200,000.

**RICHMOND**—The Air Reduction Co., 120 Broadway, New York City, N. Y., has awarded the contract for the construction of a 60 x 102 ft. concrete chemical plant for the manufacture of oxygen, nitrogen and acetylene gases, to the James Mitchell, Inc., 76 Montgomery St., Jersey City, N. J. Estimated cost, \$30,000.

### Washington

**TACOMA**—The Skinner & Eddy Corporation, 1599 Railroad Ave., S. will build a large electric smelter here. Estimated cost, \$750,000.

**VANCOUVER**—The Rand Iron Works, 608 Ingalls St., will build a furnace room. Estimated cost, \$6000.

### West Virginia

**BELLE**—The Charleston Chemical Plant will rebuild its factory destroyed by fire, entailing a loss of \$400,000.

### British Columbia

**GRAVES POINT**—The Granby Consolidated Mining, Smelting & Power Co., 713 Granville St., Vancouver, will build a by-products plant here. Estimated cost, \$1,250,000.

**POWELL RIVER**—The Powell River Pulp & Paper Co. will rebuild its mill recently destroyed by fire.

### Ontario

**HASTINGS**—The Hastings Tanning Co. will build a one and two story, 200 x 200 and 40 x 90 ft. tannery. Estimated cost, \$50,000.

**B. E. Parks & Sons, Grand Rapids Savings Bank, Grand Rapids, Mich., architect.**

**KIRKLAND LAKE**—The Wright-Hargrave Gold Mines will build a mill and cyanide plant to have a capacity of 45,000 tons per year. Estimated cost, \$150,000. A. Wendy, superintendent.

**LONDON**—The City Council will build a low level interceptor and sewage pumping plant, also sewage disposal works. Estimated cost, \$300,000. H. A. Brazier, engineer.

**TORONTO**—The Galena Signal Oil Co., 134 Royce Ave., has awarded the contract for the construction of a concrete oil plant to the Toms Contracting Co., Kent Building. Estimated cost, \$60,000.

## Industrial Notes

**THE NATIONAL ANILINE & CHEMICAL COMPANY, INC., 21 Burling Slip, New York,** announce the appointment of Mr. W. W. Jones as the manager of the essential oil and gum department. He was formerly manager of the New York office of Frederick Stearns & Company.

**THE CHEMICAL EXPOSITION COMPANY** wish to announce that they will be located hereafter at 405 Lexington Ave., New York City, instead of the Grand Central Palace, which has been taken over by the Government.

**THE UNITED ALLOY STEEL CORPORATION, Canton, Ohio,** will open a sales office at the Swetland Building, Cleveland, which will be in charge of I. J. Shults.

**THE ZIRCONIUM SYNDICATE, LTD. of Great Britain,** are now manufacturing white zirconium, practically pure. It is believed that the production of zirconia on a substantial scale and at a commercial figure has never been accomplished before outside of Germany.

**THE NEW JERSEY ZINC COMPANY** have issued a new set of books entitled "Elements," "Metals," "Roller Zinc" and "Zinc Dust" which they call a "Handy Reference Library of Zinc Products." Each booklet briefly describes certain zinc products giving information that the average person might like to know.

**THE INDUSTRIAL ELECTRIC FURNACE CO., Chicago,** makers of the Snyder Electric Furnace, are installing a five ton furnace in the plant of the Zimmerman Steel Company, Bettendorf, Iowa. It is a three-phase furnace, designed for acid operation, and will be used for general work. C. H. Atherton, manager of the Zimmerman Steel Company, ordered the installation to replace the converter which they had been using.

**THE ELECTRO BLEACHING GAS COMPANY** has suffered so many losses in its technical forces due to the demands for war purposes that it has been necessary to discontinue the Chicago office. Mr. G. R. Ellis, who has been in charge of the Chicago territory has been transferred to the Niagara Falls plant and placed in charge of the office work.

**THE PERCOL CHEMICAL CORPORATION** has just bought a large manufacturing plant in Buffalo, N. Y., and will commence operations Nov. 1, 1918. Their specialty will be electrochemical products.

**THE AMERICAN NITROGEN PRODUCTS COMPANY** announce the opening of Eastern offices in the Woolworth Building, New York City, where the usual business courtesies will be gladly extended.

**MR. R. D. KEHOE** announces that he has disposed of his interest in the Machinery Utilities Company, Inc., and severed all connections therewith. He also announces the formation of the Technical Products Company, Inc., with offices in New York, Chicago and St. Louis, for the purpose of covering special fields of work not hitherto taken up by the Machinery Utilities Company and on a broader scale. The new organization will maintain a staff of technical men for the purpose of purchasing inactive equipment and placing it in essential industries. The new organization will not compete with the Machinery Utilities Company, Inc., but will enter other fields of work.

**THE WHITLOCK COIL PIPE COMPANY, Hartford, Conn.,** announces the opening of Eastern office at 40 Congress Street, under the management of Mr. W. B. Horr, who was the former Rochester representative.

**THE PALO COMPANY, 90 Maiden Lane, New York City,** have taken over the plant of Otto P. Weisswange of Mt. Vernon, N. Y., manufacturing precision instruments, thermometers and pressure meters, to meet the requirements of the Bureau of Standards. This plant was bought mainly to fill Government orders.

**THE CELLULOSE CO., New York City,** which is financed by Vickers Co. and Nobel Co., London, will commence building the \$2,000,000 cellulose and rayon manufacturing plant recently announced by the War Department. For the duration of the war the cellulose products will be taken over by the Government for armaments; after that the company intends manufacturing acids, drugs, dyes, etc., from cellulose and other materials.

**THE BON AIR COAL AND IRON CORPORATION, of Nashville,** is building a wood chemical plant at Lyles, Tenn., in accordance with contract to supply the Government with materials for explosives manufacturing. The plant will be in operation about Dec. 1. This factory expects to produce 100,000 to 200,000 gallons of wood alcohol, 40,000 pounds of acetone, 10,000 and 10,000 bushels of charcoal per day. The Government will take all the alcohol and acetate of lime for the purpose of manufacturing explosives; the output of charcoal will be burned in the Bon Air Coal and Iron Company's iron furnace.

**RICKETTS & COMPANY, INC.,** mining, metallurgical and chemical engineers, have opened new laboratories at Room 509, 80 Maiden Lane, New York City. They are now equipped for assay and analytical work of all kinds, especially analyses of glycerin and manganese.

**MESSRS. A. E. S. THOMPSON & COMPANY,** handling large quantities of chemicals and dyes in the Oriental market, has established a branch in the Merchants Exchange Building, San Francisco.

**THE INTERNATIONAL OXYGEN COMPANY** recently sent Mr. George Quelch, one of the staff engineers, to England to supervise the installation of a 400-cell plant of I. C. C. Unit oxyhydrogen generators for the British Admiralty. Mr. Phillips Wesley, technical manager in charge of the oxyhydrogen plant and sales office of the company at Pittsburgh, and Mr. Jack Heller has joined its New York sales force, succeeding Mr. Barnitz.

## Manufacturers' Catalogs

**THE CHEMICAL CONSTRUCTION COMPANY, Charlotte, N. C.,** has published an attractive pamphlet descriptive of its service in the design and construction of chemical plants. Considerable space is devoted to a description of a chemical concentrator for the concentration of sulphur and phosphoric acids.

**THE INTERNATIONAL OXYGEN COMPANY, 115 Broadway, New York City,** calls attention to its new 400-cell oxyhydrogen generator of the company, gives dimensions and capacities, and presents working plans of two typical plant layouts of common capacity showing the extreme compactness of this new cell.

# CHEMICAL & METALLURGICAL ENGINEERING

A consolidation of ELECTROCHEMICAL & METALLURGICAL INDUSTRY and IRON & STEEL MAGAZINE

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### Victory Over Might

IN SECURING an absolute defeat of the Teutonic Powers, we believe that the Allies have extracted the Might from the German banner "Might Is Right." The obligations to the world that the German people have incurred will not be cancelled by their surrender of 5,000 cannon, 2,000 airplanes, 160 submarines and other useless war material in proportion, nor by the payment of gold indemnities. The loss that they shall feel most will be foreign good will, and try as hard as they may, they shall never be able to put warmth into the heart that has chilled.

The predominant characteristic of convicted culprits as reported by the prison welfare worker is the desire of the criminal to make it appear that he is not bad. He shrinks from making a confession of his guilt, though he finds great solace in bearing witness against some one else. Try as they may, the German people will have a difficult time to convince the world that they did not support the aims of their infamous government with heart and soul. The allied army did not merely upset the Hohenzollern autocratic militarism but it subjugated a nation which since the days of Rome has been banding into plundering hordes under the banner of "Might Is Right."

Even in the realm of the chemical industry, the wolf was the foster mother. The work of Ostwald, Haber, Nernst, Fischer, advanced into the chemical realm under the same command, "Vorwärts!" that sent the pillagers into Belgium. It was the "Halt!" by the same voice that caused dyes to be sold in all countries outside of Germany at prices designed to keep for their nitrating equipment all the Might.

### Making Blast Furnaces and Steel Works Fit

THE opinion is practically unanimous that for several years of peace, following a war of more than four years' duration, which has made its effects keenly felt in the uttermost parts of the earth, there will be trade expansion and much new construction, with a heavy demand for practically all commodities at remunerative prices. Much has been said of "reconstruction," but if the term be construed narrowly to mean restoration in the war area, the history of the period will probably show reconstruction of business throughout the world as of much more importance commercially. There will be trade expansion everywhere, new ideas leading to new ventures and much construction everywhere. The early idea that capital would be scarce after the war on account of so much destruction of property has yielded to the new conception of what can be done financially by



the immense war loans that have been so readily floated. Just for one illustration, municipalities are likely to employ the Liberty Loan methods with which their men, women and children have become so familiar, for the purpose of floating popular loans for municipal improvements, replacing the hitherto universal practice of the city fathers dealing direct with the bankers.

Before the world really starts at full speed on this work, however, there must necessarily be a period of sweeping readjustments. That is fully recognized, and the only debate to-day is as to the number of months that will be required. In the case of steel, the line of demarcation between the readjustment period and the period of world activity commercially will be drawn with particular sharpness, by reason of the fact that whenever there is a heavy demand for steel the major part of it is going into construction, into works planned by the investor, who must buy at prices bearing the proper relation to the expected returns over a period of years, ranging perhaps from ten to twenty-five, according to the nature of the venture.

Of this period of readjustment the iron and steel industry should not lose one day. It has a very important job immediately ahead of it, in making all its plant facilities, its blast furnaces, steel works and rolling mills altogether fit for the work ahead of them. Many are quite unfit now. For fully three years the productive capacity of the American iron and steel industry has been taxed. For about two years it was merely taxed in an ordinary commercial way. The industry was engaged in selling, producing and making money. For nearly a year past its governing motive has been a higher one. The War Industries Board has insisted continuously on maximum production as a patriotic duty, never mind how expensive the operations or how uneconomical some practices might be, if only they assured additional tonnage of steel to meet the great emergency. First there was the damage to plant facilities that always occurs when operations are profitable, the cost being counted and considered warranted, and then there was the extra damage, when the cost in dollars was not counted.

In the first place, all this damage must be repaired and all facilities put in the best condition. In the second place, there has been a sweeping rearrangement in the relative importance of different items of cost, whereby the cost of plant facilities does not bear the same relation to operating cost as formerly obtained. With high wage rates, labor saving machinery is indicated in many places where it was not formerly indicated. Again, under the stress of demand for the last possible ton of steel, capital expenditures have been made with a view of increasing tonnage output rather than reducing cost per ton. The former continuous progress toward more and more economical methods of production has been very largely interrupted. With its greatly increased tonnage capacity the industry must now be much more concerned with capital expenditures that will reduce cost of production than with those that contemplate merely an increase in tonnage. Again, while the iron and steel industry has never had all the capital its engineers and metallurgists desired to invest, it is better provided with capital than ever before as a result of several years of unusual profits. Thus the industry finds itself in an entirely new set of conditions.

The big job thus indicated as lying before the iron and steel industry is one that must be done quickly if it is to be done to the best advantage. The chief time for it is the interim period, of uncertain duration, between the heavy demand for product that has hitherto existed and the heavy demand that is to come when trade has found its stable basis for a period of years of general activity. While the investor in construction work that requires steel may wait until costs find their level, the producer of steel cannot keep him company, for he cannot revamp his works and produce maximum tonnage at the same time.

### Commercial Bribery— Trade Commission Acts

THE FEDERAL Trade Commission on October 24 ordered the firm of John F. Buckie & Son, makers of printers' rollers, Chicago, to discontinue the practice of giving gratuities or presents to employees of their customers or to those of competitors' customers, with a view to influencing the purchase of supplies. Another concern was cited to appear before the Commission on December 6 to answer an allegation to the effect that it had been practicing commercial bribery in the sale of its dyestuffs.

This sort of thing must stop. The greatest of our coal-tar dye concerns has taken the firm stand that no bribery shall be practiced and we understand that the leading houses in the industry are following suit. Before the war the bribery of dyers in the color industry was nothing less than outrageous. We have already quoted a remark of a veteran of the dye business which we shall repeat. "Everybody did it," said he, "and the only difference between the Americans and the Germans was that the Americans knew it was wrong and the Germans didn't." He is a man of charitable mind, but perhaps he was right. The point that we want to make is that the practice is too corrupting to allow anybody to engage in it. The penalty has been made severe, but that will not stop it unless there is an enlightened and honest public opinion to back up the law.

We recall one cheerful old hypocrite who sent handsome sums to the persons he would bribe with the memorandum that the remittances were for pew rent, and he soothed his gravely conscience with the observation that there was nothing wrong in inducing people to go to church. He was not in the chemical trade, we are glad to say. The legend is also told of a late philanthropist who lived his bespangled days in red hot affluence that early in his career it was his occasional habit to send his card in to the railway officials to whom he desired to make sales, accompanied by a sealed envelope. The latter contained the half of a thousand dollar bill that has been torn in two, and with it he gave the message that he had with him the answer to the letter. The answer, of course, was the other half of the bill. This seems hazardous, but he knew his trade.

There is a great element of sport in crime, which is its chief appeal to some minds. And there is humor in it, as there is in most adventure. But it is expensive, viciously expensive to the general welfare. Bribery in trade is also like cheating at cards in that it indicates a fault in him who practices it that renders him unfit to associate with those who do not cheat. Bribery



is a disease, whether it comes through the front door or the back, and it soon spreads itself, no matter how great the effort to hide it.

There are some puling, whining polyps that do not ask for bribes out and out, but always and forever intimate that if they only had certain advantages they could do a great deal for the man with goods for sale. They beat all around the bush with the mumble that they don't want anything but what is right—and then they begin all over again and go on to tell how trustworthy they are keeping secrets. They might also be called the mosquitoes of business. If somebody were to spit upon them they would drown.

### Employment Managers and the Wage Earners

WE PRINT elsewhere an article by Mr. C. T. CLAYTON, Director, Training and Dilution Service, United States Department of Labor, on "Who and What Is the Employment Manager?" It is propaganda sent out by the War Industries Board with a view to avoiding after-the-war disorder. When we bear in mind that some twelve million men and women are now engaged in the production and distribution of war supplies, it stands to reason that the transfer, in the main, of so vast an industrial army to the arts of peace calls for intelligence, caution and character. Even more serious will be the placing of returned soldiers.

We are persuaded that the art of employment must receive more intelligent attention hereafter in industry than it has received heretofore. To aid in this the Employment Management Section of the War Industries Board has provided courses of instruction at certain institutions of learning to which employers may send accredited representatives for the purpose of informing themselves on such theory and recorded practice as is available on the subject. The courses run from six weeks to two months and are conducted under the auspices of the Departments of Labor, War and Navy, the United States Shipping Board and the Chamber of Commerce of the United States. Tuition is free.

As industry has grown bulky as well as great, employers of thousands have not thought to urge their men to read as well as to think, although this is done in the Army. Nevertheless industrial workers have read and thought, and they have reached some amazing conclusions, among which is the dictum that life, in nearly all of its aspects, is a problem in economics. The standardized socialist will quote statistics and figures to prove this until any one unfamiliar with his arguments becomes bewildered. And yet it is no strain upon the mind to grasp the idea that there is far more than economics in the business of living. One trouble is, though, that clear thinking is hardly possible when conditions are unfavorable, and unfavorable conditions often obtain in industrial life.

Where poverty pinches life is a problem of economics. We mustn't forget that. On the other hand, as soon as decent living conditions arise, economics in a personal sense becomes but a function of sanity, while taste and habit play more important parts. Psychologists say that if a statement is made to a child constantly and repeated without contradiction, by the time he grows up he is likely to regard the statement as a fact, no matter how absurd it may be. Now a surprisingly large number

of factory hands have grown up under the constant iteration and reiteration that life is wholly a problem in economics, and we have to meet this illusion almost as an *idée fixe* time and again. Carried to its ultimate conclusion and without the development of taste and the cultivation of habit it leads to anarchy, riot and Bolshevik terror. But the idea is exceedingly popular and, we repeat, when poverty pinches it is right; then economics becomes a question of life or death.

Deputy sheriffs do not cure the illusion. Neither will overpayment of wages, and letting it go at that. We have long emphasized the fact that the feeble minded drift naturally into industry and that labor organizations that carry them as equals do so to their great detriment. According to a Government publication, from five to fifteen per cent of all applicants for jobs in industry are feeble minded. Give them more than a hundred dollars and you are buying trouble.

Industrial obligations are not fulfilled by the payment of wages. They are not even completed by good housing conditions. Something more is required, and that is the development of an enthusiastic, loyal, intelligent working staff. If an industrial organization degrades the quality of citizenship of its workers and by its own fault or neglect permits a situation to arise whereby their progeny become crippled in mind or wayward, the country is better off without that establishment. We cannot afford to make bad Americans, either directly or indirectly, whether the parents be born here or in Italy or Russia or anywhere else. Our boys are fighting nobly for us; we mustn't spoil their land or their people, now or at any other time.

We have no specific cure to recommend. Sometimes a bonus system works and sometimes it doesn't. Sometimes an employment manager is a great help and sometimes he is an ass. The point we want to make is that the workers in an industrial establishment are citizens, real or prospective. We live in a democracy. It is the measure of their intelligence which in the end will guide our country. The responsibility for their development in mind and understanding and in the art of living is a big and solemn thing. We know an otherwise excellent man engaged in industry who misses this point. The more he prospers the worse it is for his home town.

### Pure and Applied Chemistry in England

WE PRINT elsewhere the presidential address of Professor WILLIAM JACKSON POPE before the Chemical Society of England, and we commend it to our readers for its sound doctrine, clear vision and its happy grace of expression. The situation of pure and applied chemistry in England in 1914 was not exactly the same as it was in America but in a way we were all in the same boat. We listened devoutly to the siren voices of German privy councillors, professors, consular agents and commercial travelers who sang in chorus the refrain that chemistry cannot thrive outside of Germany. We lacked the training, the scholarship, the precision of thought and habit and every requisite quality to practice chemistry in its refinements, they declared—and we listened attentively without calling their bluff.

We congratulate the Chemical Society on the happy selection of its president and we wish it all success under his guidance.

## Readers' Views and Comments

### Measuring Odors

To the Editor of *Chemical & Metallurgical Engineering*

SIR:—In commenting on the paper of V. C. Allison and S. H. Katz, you say, on page 549 of the October 1 issue of *CHEMICAL & METALLURGICAL ENGINEERING*: "So far as we are aware, this is the first instrument designed to establish olfactory standards, and we sincerely hope that studies on the subject may be continued." Unfortunately for the glory of our American chemists, Allison and Katz have been anticipated by a Hollander, Professor H. Zwaardemaker of the Physiological Laboratory at Utrecht, who not only has designed an instrument for a similar purpose but has obtained a whole series of results of far-reaching significance by its use. A popular, although quite comprehensive, exposition of this field is given by Professor Zwaardemaker<sup>1</sup> himself, while another clear statement of these researches will be found in a general article by J. Languier des Bancel's.<sup>2</sup>

In passing, attention may be drawn to the fact that the word "odormeter" adopted by Allison and Katz hardly corresponds to the best English usage. Should it not be either "odorimeter" or odorometer"? I have seen the assertion<sup>3</sup> that Zwaardemaker speaks of "olfactometry" when measuring the sensitiveness of the sense of smell, and of "odorimetry" in determining the intensity of odors, although my impression is that he has given up the latter term, using the olfactometer for both purposes. Before leaving the subject of Zwaardemaker's work, I wish to draw attention to the Utrecht dissertation of J. Hermanides (1909), which contains extremely important information on an interesting phase of the work resulting from the application of the olfactometer in Zwaardemaker's laboratory. I have not been able to find this pamphlet in the larger Chicago and New York libraries, and would appreciate any hint helping me to locate a copy.

The latter part of your comment, wherein you express the sincere hope that the work may be continued, must receive a most hearty second from all American chemists, for there is surprisingly little being done in this promising field of the relation between chemical constitution and odor.<sup>4</sup> To illustrate that interest in this subject is not altogether dormant, attention may be drawn to the following free translations from the only book that claims to treat the matter.<sup>5</sup> In the preface, Cohn writes:

"A knowledge of the nature of perfumes, their physical, chemical and physiological properties, is a necessary preliminary for their synthesis. Too much attention cannot be paid to this subject, if for no other

reason than the desire that German science may assert its preëminence in this field also of chemical activity." Again, on page 64: "The investigation of perfumes, the determination of their constitution and their synthesis, has made the most progress in Germany, because here strictly scientific principles and not empiricism has been the guide. Not without reason do the French see in this successful co-operation of science and industry in Germany a serious threat to the existence of their own industry."

Personally I believe the subject of smell and odors will eventually be of great significance to chemical science and industry and that it will attain an importance transcending even the goal sought by far-sighted chemists in the line of synthetic perfumes; it is therefore a matter of satisfaction to see American chemists doing good work in this neglected field. In closing allow me to compliment the member of your staff who is so alert as to recognize important work and who acts on his judgment in urging its continuance.

V. H. GOTTSCHALK.

Director of Research, American Cotton Oil Co. and subsidiaries  
Chicago, Ill.

### Copper in Converter Slags

To the Editor of *Chemical & Metallurgical Engineering*

SIR:—Your editorial of April 15 and Mr. Forest Rutherford's letter in your issue of July 15 lead me to give some of my own observations on the behavior and composition of converter slags.

Mr. Rutherford's experiments confirm my belief that it is impossible thoroughly to clean converter slag by pouring it into blast-furnace settlers. This practice would scarcely have gained any popularity did not the great dilution with furnace slag mask the true losses.

Some years ago I determined the copper as sulphide and oxide or silicate in an average sample of converter slag made during a considerable period at a large smelter. These were 0.48 per cent and 1.44 per cent, respectively, showing that 75 per cent of the total copper existed in the oxidized condition, although there was 1.70 per cent sulphur in the slag, more than enough to combine with all the copper present. This shows clearly why settling alone does not produce clean slags. If this slag were poured into a blast-furnace settler a little of the oxide might be reduced by contact with the matte, but surely not a large proportion of it.

Mr. Rutherford evidently believes "that converter slags cannot be cleaned without resmelting them, and in doing so, changing the chemical composition." If by "composition" he refers to the combination in which copper exists in the slag he is evidently right, but if to the relative proportions of silica, iron oxide and other bases, I believe he is only partly so. In support of this I shall quote the results of experiments by Mr. John W. James (*Eng. and Min. Journal*, vol. 97, p. 1114).

Mr. James passed into a reverberatory furnace converter slag which by settling had been reduced in copper content to 1.25-1.50 per cent. By a treatment with green poles and charcoal 40 per cent of the

<sup>1</sup>Ladenburg, "Handwoerterbuch der Naturwissenschaften," Band IV, pp. 967-975 (G. Fischer, Jena, 1913).

<sup>2</sup>L'Odorat: Revue generale et critique," Archives de Psychologie, X, 1-46 (1910).

<sup>3</sup>Schimmel's Semi-Annual Reports, English edition, October-November, 1904, pp. 194-199.

<sup>4</sup>Gertrud Woker, "The Relations Between Structure and Smell in Organic Compounds," Journ. Phys. Chem., X 455-473 (1906), is probably the only contribution in an American scientific journal in this field.

<sup>5</sup>Georg Cohn, "Die Riechstoffe," in Bolley's "Technologie," VI 2 (Braunschweig, F. Vieweg und Sohn, 1904).

copper was reduced. He then threw in a little pyrite and brought the copper down in a few minutes to about 0.4 per cent, a normal loss in reverberatory smelting. He concluded that the copper was present in the oxidized condition, and thought there was insufficient sulphur in the slag to combine with all the copper. He suggested that where iron flux was not required the treatment with pyrite would be a satisfactory solution of the problem.

Where converter slag is treated in reverberatory furnaces it is usually charged with roasted or raw concentrates, or both. A fair reduction is sometimes obtained in this way, but I would suggest the addition of pyrite in large lumps as being preferable. These would sink to the bottom and lose half their sulphur by heat alone, the vapor of sulphur rising through the supernatant slag and having an excellent opportunity of reducing the oxide of copper. If siliceous and calcareous ores were available these could of course be added to advantage, but I believe the reduction with pyrite is the essential thing, and no great change in chemical composition would be necessary to produce a satisfactorily clean slag.

Even when smelted in a blast furnace, converter slags are responsible for increasing the copper content of the furnace slag to some extent, both by increasing its specific gravity and consequently hindering the separation of matte and slag, and by introducing oxidized copper. Direct determination of oxidized copper in furnace slags has shown that this loss increases as the converter slag on the charge is increased. This is similar to, though less than, the increase in slag loss when copper silicate ores are smelted in a blast furnace.

Your editorial raises the broader question: How is copper held in a furnace slag? It is not my wish to go fully into this question, as I have already discussed it in detail. (*Eng. and Min. Journal*, vol. 100, p. 215, 263, 305). But I may state that analyses which I made of blast furnace slags from three large plants showed that from 50 per cent to 75 per cent of their copper was in the oxidized condition. The proportion would probably be lower with a heavy sulphide charge.

FRANK E. LATHE.

Chuquicamatn, Chile.

## Role of Colloids in Chemical Processes

To the Editor of *Chemical & Metallurgical Engineering*

SIR:—I read with much interest your article on the "Role of Colloids in Chemical Processes" and note that in numerous fields colloidal action has been recognized.

Under the heading of "Metallurgy" however, nothing has been said of the relationship of colloid chemistry to the flotation process. Some interesting facts are related under "Soap Manufacturing" and it is queer that the very fact that the flotation process is based solely upon colloidal chemistry actions is not more recognized. Only a few days ago I read an article by Jackson Pierce in the *Mining & Scientific Press* on the action of colloids in the flotation process, based upon the assumption that slimy mineral and gangue represent a colloid; in other words, written with a total ignorance of the actual meaning of colloid chemistry, yet it is beyond all question of doubt that just the same as in the soap industry and in the dye industry definite colloidal actions are recognized and utilized so the flotation process is absolutely fundamentally based upon the formation of colloids from the oils, tars, coal-tar intermediate products

and the like used, and it seems too bad that probably the biggest percentage of flotation men are still laboring under the impression that mud in the flotation cell represents the colloids and that the true colloid action in the flotation process is therefore overshadowed and drowned by these mediæval ideas. For over a year I have been writing articles from time to time trying to impress upon the flotation industry the importance of research work in the direction of colloidal chemistry, but so far with little success.

I have installed numerous and expensive devices in my laboratory to test out such colloidal actions and am fully satisfied that colloid chemistry absolutely explains the mystery of the so-called flotation phenomena. I have corresponded with Dr. Fisher, who translated Ostwald's "Lectures on Colloid Chemistry," and he joins me in this opinion.

As you say in your note that such publication is timely, I suggest that you open a discussion on that subject and I shall be glad to enter it with what results I have obtained in my own research work.

Joplin, Mo.

A. SCHWARZ.

## Reinforced Concrete vs. Salt, Brine and Sea Water

To the Editor *Chemical & Metallurgical Engineering*

SIR:—In your issue of Oct. 15, 1918, there appears an article by H. J. M. Creighton on the subject "Reinforced Concrete vs. Salt, Brine and Sea Water."

It seems to me Mr. Creighton has drawn conclusions which are scarcely warranted by the facts presented. Without a knowledge of the actual location of the various structures referred to in this paper it is difficult to get at the facts, but it is quite apparent from a careful study of the photographs submitted that at least in many of the cases the structure was either improperly designed or improperly constructed.

The regulations of the Joint Committee on Concrete and Reinforced Concrete and all properly prepared specifications for such work require that the reinforcement shall have a protection of concrete of not less than one inch. The Joint Committee devotes a paragraph in its report to the subject of corrosion of metal reinforcement which reads as follows:

"Tests and experience indicate that steel sufficiently imbedded in good concrete is well protected against corrosion, no matter whether located above or below water level. It is recommended that such protection be not less than one inch in thickness. If the concrete is porous so as to be readily permeable by water, as when the concrete is laid with a very dry consistency, the metal may corrode on account of the presence of moisture and air."

A careful study of photographs 3, 7, 8, 9, 10, 12 and 15 would indicate that the metal did not have one inch of protection, and undoubtedly rusting of the reinforcement and, therefore, cracking of the concrete would have occurred in the presence of moisture, regardless of whether the moisture contained salt, brine or sea water. It would also appear from some of the other photographs that the concrete in several cases was not of the best quality, possibly being porous and thus subjecting the reinforcement to early and undue corrosion.

Chicago, Ill.

W. M. KINNEY.



## Western Chemical and Metallurgical Field

### Manganese In California

SUCCESSFUL prospecting and development of manganese-producing mines have gone on at a remarkable rate since Americans were convinced that they must supply the deficiency of ore formerly supplied by ship from Brazil and elsewhere. Not only is a very considerable quantity of high-grade ore now being produced for direct smelting into high-grade ferromanganese, but much ore is being concentrated to eliminate undesirable silica and other impurities, notably at Philipsburg, Mont., as described in our issue of June 15, 1918.

#### ORE DRESSING TESTS

E. A. Hersam has conducted some experiments on ores of the latter class, and the results are given in the University of California Publications in Engineering. The results encourage the author to say that if each ore is studied carefully before large expenditures are made for a treatment plant, there will be found abundant reasons for developing the deposits of low-grade ores at this favorable juncture. It is elsewhere officially reported that more than 200,000 tons of siliceous manganese ores are now developed in the Coast regions alone.

Little of the California ore promises a successful mechanical separation except after fine crushing. The manganese minerals are of low density, often approximating that of the gangue, and slime excessively during crushing. Thus while a clean concentrate can be made on machines acting under the principles of hindered settling, most of the values appear in the slimes of an intermediate grade and are difficult if not impossible to treat. Flotation tests on this material were unpromising in every way. Magnetic tests were most favorable, indicating that about 75 per cent of the manganese may be recovered in marketable grade. On the other hand, electrostatic tests were erratic and unsatisfactory. Very encouraging results resulted from lixiviation tests. For instance, 40-mesh ore was leached with a solution containing 10 per cent sulphuric acid and 10 per cent ferrous sulphate, circulating through a diaphragmed electrolytic cell, operating at 2.5 volts and 100 amperes per square meter. Extraction of the manganese from the ore was satisfactory; the metal was deposited as a hydrated dioxide (80 per cent  $MnO_2$ ) on the anode, and the acid and reducer continuously regenerated. Certain features of this process have received careful examination, others are under minute investigation. Deposition may attain the rate of 1.62 grains of dioxide per ampere hour, and the cost of the process on a large scale is estimated at \$15 per ton of product, exclusive of electrical energy.

#### PRODUCTION OF SILICO-MANGANESE

In the meantime the Pacific Electro Metals Co.'s plant at Bay Point (briefly described in our issue of Aug. 1, 1918) is reducing siliceous ores to an alloy of iron, silicon and manganese. On account of the very small slag volume produced by their electric furnace, the recovery of manganese is excellent—approximating 90 per cent—and the current efficiency is superior to that

when producing ferromanganese. The alloy is not widely known among American steel makers, although it was imported in considerable quantities prior to the war and is favorably regarded by at least one of the largest steel companies. France, England and Sweden have all been producers of this alloy, and are producing in quantity at the present time, while it is thought that it supplies practically all the manganese used by the German steel works. Electric furnacemen are fond of saying that in an alloy, carbon and silicon are mutually exclusive, consequently properly made silicomanganese may contain less than 0.5 per cent carbon, which should make an attractive material for use in the production of low carbon steels and ingot-iron.

#### FERROMANGANESE ON THE COAST

At least three companies are equipped to produce ferromanganese on the Pacific Coast. The Western Reduction Co. of Portland, Ore., has a 700-kw. furnace, the Billroe Alloys Corporation of Tacoma, Wash., a 500-kw. furnace, while the pioneer Noble Electric Steel Co. has been devoting a great deal of attention to ferro-alloys for many months past and has now two 1500-kw. furnaces in operation at Heroult, Cal. The Noble company largely produces its own raw materials; its production of high-grade manganese ore amounts to about 600 tons per month from four mines in Shasta, Tehama and San Luis Obispo counties. Charcoal used for a reducing agent is produced by them in two localities in Mendocino County, one a pit-burning operation, seasonal in character, and the other in beehive kilns, which are continuously operated. Iron ore and fluxing limestone are both quarried from large high-grade deposits near the furnace-plant.

A considerable part of the 70 per cent alloy is consumed in the five open-hearth plants on the Pacific Coast. Since three-quarters of the steel produced in this region is sold directly to the Fleet Corporation, it is apparent that the local production of necessary deoxidizers is an essential war industry. The Noble Steel Co. also produces an 80 per cent grade of ferromanganese, which is shipped east to such plants as have permission to use it from the Ferro-Alloys Board of the Iron and Steel Institute. About 500 tons of alloy are produced monthly, and present indications are that this production can be maintained profitably even after cessation of hostilities.

#### National Potash Company's Plant Destroyed

During the latter part of September the potash plant of the National Potash Company, situated at Antioch, Nebraska, burned to the ground.

The National Potash Company is one of the "big six" in the Nebraska field as far as resources and plant are concerned. Construction on the plant was started only last November, and it had hardly been tuned up to capacity, due to delays in construction and low water in the lakes. Thus the greatest daily output was approximately 20 tons, and the total production had hardly affected the total for the region when the plant was destroyed. The remaining large producers are the Pioneer Potash Products Co., at Hoffland; the Nebraska Potash Works Co., the American Potash Co. and the Alliance Potash Co., all at Antioch; and the Hord Alkali Products Co., at Lakeside.

## War Emergency and Reconstruction Conference to Be Held at Atlantic City

**P**RELIMINARY plans for the War Emergency and Reconstruction Conference of War Service Committees to be held at Atlantic City Dec. 4, 5 and 6 are announced by the Chamber of Commerce of the United States through the general secretary, Mr. Elliot H. Goodwin.

Reconstruction will be given a prominent place on the program, as it is recognized this subject must be taken up by business men to the end that there may be placed at the command of the Government all available sources of information. The work of reconstruction suggests the creation of a federation of all war service committees that whatever study and planning is carried on may be on behalf of all business. War industries and non-war industries are concerned equally in the determination of reconstruction problems. All European countries already are under way with reconstruction plans.

The Atlantic City conference, a call for which was sent out last week by the War Service Executive Committee of the Chamber of Commerce of the United States, will include four general sessions and numerous group and committee meetings. Into the final session will be brought for final action all the proceedings of the meetings.

There will for four general sessions participated in by all the delegates. On Dec. 4 there will be both morning and afternoon sessions and on Dec. 5 and 6 morning sessions. The Chamber is engaged now in obtaining the best speakers available to discuss among others the following suggestions: reconstruction, industrial relations, raw materials and their control, price control, economic legislation affecting combinations, export and import operations, finance, etc.

The conference will be divided into groups at three sessions, the first to be held on the evening of Dec. 4, the second on the afternoon of Dec. 5 and the third on the evening of the same day. On the evening of Dec. 4 each war service committee will meet with its chairman to consider the problems of reconstruction as they affect that particular industry as well as to take up other problems which the war has demonstrated are vital to industry. On the afternoon of Dec. 5 the war service committees will meet in groups which are related as to their use of basic materials and as to their distribution problems, etc. With these groups will meet the commodity or section chiefs of the War Industries Board.

Related groups will form themselves into ten major groups on the evening of Dec. 5 to take up the question of raw materials, price control and subjects arising from related group meetings. After the general meetings of the committees of the related groups and of the major groups it is hoped there will be presented definite recommendations covering the reconstruction period, with the possibility of creating an executive committee empowered to gather data and to function with industries to meet the many problems that the nation's industries will be called upon to solve with the end of the war.

## War Industries Board May Be Reconstruction Agency

By WINGROVE BATHON

Washington Representative, McGraw-Hill Company, Inc.

**I**N CONNECTION with the possibility of a Reconstruction and Readjustment Agency being created by act of Congress, opinion is crystallizing in Washington along the lines that the members of the War Industries Board will most likely be appointed to this work in case the Overman bill, which is an administration measure and which provides for a commission of five members to be appointed by the President, is passed by the present Congress. There is every expectation that this bill will be passed, and the likelihood of its passage has been added to by the defeat for re-election to the Senate of Senator Weeks, who proposed a reconstruction measure which would have created a reconstruction agency composed of members of Congress.

In Washington it is now believed that if the Overman bill is passed President Wilson is likely to name as members of the Reconstruction Commission men like Bernard M. Baruch, chairman of the War Industries Board, and some of his principal associates. It is pointed out in Washington that while Senator Weeks has been defeated his idea of a legislative reconstruction agency has not necessarily died. In other words, it is expected that during the life of the present Congress Senator Weeks' idea will be pushed. But it is also pointed out in Washington that there is every likelihood that if a Congressional reconstruction agency were created, even admitting that the consent of President Wilson to do so could be obtained, the new Congress which takes office March 4 next would likely legislate out of existence, possibly by failing to appropriate money, the creature of the present Democratic Congress. All the present signs in Washington, however, tend to show that the Overman bill will be passed and that the machinery of the War Industries Board will be turned into after-the-war work behind the commission to be appointed under the Overman bill, under the probable leadership of Mr. Baruch as chairman of the new commission.

It is pointed out in Washington that the present agencies of the War Industries Board are in possession of complete data and information concerning the industrial, commercial, financial and transportation resources of the country. For this reason there are many who believe that the War Industries Board is the only agency equipped with machinery and supplied with the necessary information to give suitable guidance to business for after-the-war work.

There is no means of ascertaining or predicting what effect the elections of Nov. 5 will have upon business and the necessary reconstruction period to follow the war. It must be borne in mind that a great number of Republicans newly elected to the Senate and the House will not take office until March 4, 1919, when a new Congress will come into existence. There has been much newspaper comment to the effect that if the Republicans gained control of the House and the Senate there would in all likelihood be an extra session of the new Congress early next year at which members elected Nov. 5 would take their seats. It seems, however,

extremely unlikely that a Democratic President would call an extra session of a Republican Congress to deal with business matters such as will be involved in the reconstruction period, and it is almost certain that the present Democratic Congress, in view of the foreign situation, will hold on and remain at work in Washington until the very last minute before March 4.

Since the armistice was signed, members of the War Industries Board, more particularly committees of that board, are announcing in Washington their intention of preparing to return home and get ready for the reconstruction period which they must face in their own businesses. In some respects this attitude, while natural, is greatly to be regretted, according to the best opinion obtainable in Washington, because of the growing belief that the War Industries Board, which has done so much to guide business during the war, is so well fitted to continue to guide business during the reconstruction period.

## Address to Society of Chemical Industry\*

BY CHARLES E. SHOLES

PERHAPS you are as bored as I am to hear public speaking interspersed with stories. But when your committee overruled my protest and selected me to serve as Chairman of the Society of Chemical Industry, I immediately thought of the man up state who went into one of our New York hotels and ordered frogs' legs and got a check at \$2 a portion. He was furious and offered to furnish all the frogs' legs the hotel could use for a year at 10 cents a dozen, and a contract was duly signed. But no frogs' legs were ever delivered, and the man from up state finally admitted that he had been "deceived by the noise." I think that your committee was probably "deceived by the noise." However, we are all learning a good bit of discipline these days, and when your committee says "Carry on," there is nothing for me to do but obey.

But I want your help. Certainly organizations of this kind cannot be negative. They are either like a female auxiliary of masculine forces, or they will wield a real influence in making this wounded world whole again and in preparing our industries for the new conditions they must meet hereafter.

I do not believe that we are going to exterminate the German race or disposition. We are going to give them a severe beating, but after it is all over the same old dog will be wagging the same old tail outside the same old door to our markets, and we must see to it that he gets nothing which may be needed by our children. Our captains of industry can do much. You can do much. The Society of Chemical Industry should be an effective means of getting together.

And now may I presume to say a word concerning my recent experience and experiences? On the way to the train on that first day in the uniform of the Service a number of privates and junior officers saluted me, and a companion remarked it, until I explained (as I am very glad always to continue to realize) that it is the uniform, not the man, that is saluted. Also I hope it

is only for this reason that when one of our clean American boys clips his heels together and stands very erect and gives this uniform a snappy salute, I always have a sneaking wish to swap clothes and everything else I have for his youth and his opportunity of closer contact with this great race between good and evil.

And speaking of races, a professional runner once told me that the way to win a race was to "run as hard as you damn can—and then harder." Although this war is largely an industrial proposition and industries have been prolific in sacrifices, and I believe in them with all my American brain and blood, some of our best industrial racers got a bad start. They seem to have confused the real meaning of the tax on surplus profits, and I have repeatedly heard men contend for a high price, because "80 per cent of the profit is returned to the Government in taxes." But the facts are that the surplus profit tax is only designed to prevent some such bad behavior as we are trying to stop in Europe.

I am still looking for that officer who wears spurs to keep his feet on his desk. I haven't found him, but I have found the hardest-working lot of men I have ever seen striving earnestly with the biggest business proposition on earth, and accomplishing so much that is commendable that the exceptions and faults should be most readily forgiven.

And I'll tell you a secret—they are the best paid men on earth, because, though they only receive small sums of money, they are infinitely more proud of their jobs than any other group of men I have ever met.

May I take a moment more to ask your interest in some of the "C. P. heroes" of this war, who may be overlooked if you allow it? At a recent Sunday luncheon I met a Captain of Engineers who had just returned from France. He was a red-headed American boy and was one of that bunch that held the Hun with only pick and shovel and revolver for many hours—until many were dead and a few were succored by the Regulars. He told us about the barrage, and how much easier it was for an officer who was walking about and looking after his men than it was for the private who could only hug the bottom of the trench and wait until it was over. When this chap tried to pull a pipe from his kit bag, a soiled and broken cardboard box fell out and spilled a French and American Cross of Valor on the floor.

Some months back a nitric acid plant was shut down for want of men. You all know what a charming job it is to feed nitrate of soda into hot apparatus amid choking fumes during a hot and stifling day or night. The men could get much more agreeable work in the ship yards a few miles away. More and more pay was offered until the rate was extravagant, but no men wanted it. Then the superintendent called a meeting of the men and explained what nitric acid meant in the war program, and asked for volunteers. About five or six men answered, and "carried on," and during the next week they got five more, then that crowd got ten more, and so on. That plant has been running full ever since, and to my mind those chaps are just as deserving of the praise and gratitude of our nation as the man who goes over the top over there.

If I have said anything which any of you do not like, I am sorry. If I have said anything which will help you or others, then I can only add, "Carry on."

\*Chemists' Club, Oct. 25, 1918





## Gas Warfare, Both Offensive and Defensive

An Account of the Progress Made in the Development of Gas Warfare Since the First German Attack at Ypres on the Canadians—Lethal and Neutralizing Types of Gases—Containers, Shells, Grenades—Types of Masks

MAJOR H. W. DUDLEY, R.E., of the British-American Anti-Gas Service delivered a lecture on "Gas Warfare, Both Offensive and Defensive" at the first meeting of the season of the New York Section of the Society of Chemical Industry, held at Rumford Hall in the Chemists' Club, Oct. 25, 1918. Major Charles E. Sholes, the honorary chairman, presided.

Major Dudley introduced the subject by saying he had spent some time with American troops in France while they were in contact with British troops, and he took pleasure in saying that he found, without exception, the soldiers of each nation filled with great admiration and respect for those of the other and that the fullest co-operation has existed between the British and American armies in regard to gas warfare.

Although gas warfare is but one year old in the United States, there are already, all over the country, great works established for the production of gas munitions, and all of the many developments brought out here are offered immediately to the British army. He desired to lay special emphasis upon the evidences of good will in this respect that had come before him. Only a short time ago a gentleman engaged in making gas warfare material in this country had written him that he understood the English were having trouble with a certain feature of a necessary process. He added that it had been his good fortune to overcome the difficulty and he offered his entire research and practice to the British Government in the interest of the common cause.

The development of gas warfare has been somewhat like the old game between the armor plate and projectile

manufacturers in that it has involved a constant race to get ahead between offensive and defensive. All nations have long known its possibilities, and at the Hague Convention in 1899 it was agreed that poison gas should not be used in war. The Germans broke the convention and delivered their first attack on April 22, 1915. It is interesting to note, however, that whenever any act of extraordinary villainess was perpetrated by the Germans there was likely to be some accompanying propaganda. Thus there appeared an official German communiqué in July of this year, when they expected to succeed, that gas warfare originated with the British Admiral Donnell. The reference is probably to a British admiral of that name who was born in 1775 and died in 1860, and his entire record in relation to the subject was his caution to his Government that asphyxiating gases could be used in warfare. Again, before they made their first attack there were charges brought in official German army communiqués that the English were using poison gas against German soldiers, claiming that this had been done as early as March 1, 1915. The purpose was evidently to prepare the home conscience as well as that of neutrals for the proposed innovation. The first British gas attack actually did take place in September, 1915, and not before. There is every reason to believe that the Germans now bitterly regret that they ever began it, for it is evident that the morale of their army has suffered under it. Captured letters indicate their genuine fear of it and *Die Vossische Zeitung* has published eloquent jeremiads on the subject. And if they only knew what is now being hotted up for them they would grow even more sore depressed.

Enormous amounts of gas are necessary, which limits the substances which can be used. They must be easily prepared and so plentiful that by constantly threatening the enemy with them his efficiency is impeded.

#### FIRST ATTACK WITH CHLORINE

The first attack was with what is called the cloud method, near Ypres on April 22, 1915, with chlorine. It was carried in cylinders containing about 44 lb., and these were provided each with a siphon, extending to the bottom, through which the gas, when liberated, escaped through a valve at the top. The siphon provided for the regularity of escape and the cylinders emptied themselves in about three minutes. They were placed in holes before the trenches and covered over so that they might not be detected. To make the attacks more effective toward the end of 1915 the Germans added about 20 per cent phosgene (carbonyl chloride) to the chlorine.

The method has limitations and has been largely, but not wholly, abandoned. It is effective only under favorable weather conditions with the wind blowing in the right direction and at the desired velocity. To be entirely successful it is necessary that the enemy have defective respirators or none at all, although even with good protection and good discipline there are always some casualties in a cloud attack. The Russians, for instance, once had some 10,000 casualties from a comparatively small amount of gas, due to inadequate preparation. In captured German documents it was recorded that their pioneer gas troops liberated 3600 tons of gas and killed 35,000 men with it. Whether this is true or not, it is well to remember that the behavior of the Canadians in holding the line near Ypres and putting up at least enough defense to keep the Germans back when this kind of warfare was considered unbelievable, when they did not know what it would do to them or whether more was coming or not, and when they had no defense against it, was one of the greatest and bravest achievements in this or any other war, and it undoubtedly saved the Channel ports.

There are not many gases suitable for cloud attacks. A suitable gas must have a low boiling point to force itself out of the cylinders, it must have high density to give it adequate covering quality, and it must be stable. Chemically active gases have been found easy to defend against in cloud attacks, whereas those that are chemically inert present greater difficulties. Referring again to the relation of gas clouds to the wind, Major Dudley recalled that in April, 1916, about a year after their initial effort, the Germans released a cloud against the British in a light easterly breeze. Just as the cloud was formed the wind shifted and blew the gas back over the German trenches and caused them 1500 casualties. There is one little detail that the Germans neglected to provide for in their gas offense: the prevailing winds on the western front are from the west. This inadvertence on their part has not been remedied even to this day. Another difficulty is that whereas high concentration is required, the highest concentration is in the immediate neighborhood of the trenches of the offensive side and, of course, the gas constantly diffuses.

Casualties depend upon the success of the following three elements:

1. Surprise. Cylinders must be put into place secretly

and hidden. It is a great help to the enemy to know that a cloud attack is to be launched against him with the next fair wind. Escaping gas also makes a noise and gives an alarm.

2. Penetration of the hostile respiration. This is theoretically possible and can be realized, actually, on a limited scale.

3. Exhaustion of hostile respirators. This is theoretically possible but practically, owing to the enormous quantity of gas required to neutralize the chemical filling of a modern respirator under field conditions, the method of producing casualties is unattainable.

When the high and really (*wirklich*) privy councillors of the All-Highest (of whom Professor Nernst is said to have been a leader in the gas business) discovered that the timorous English and decadent French did not give in to their clouds of terror, the next and obvious thing to do was to fill shells with gas. The first gas-filled shells were employed in an attack against the French on May 15, 1915, which was the second step in gas warfare. With shells a wider range of gases is available. Two main types are in use, of which one is lethal and the other is called "neutralizing," the idea of the second being to hamper the opposing army and to put its men, at all events for the time being, out of action. They began with what are called lachrymators, or tear shells. These cause temporary blindness, among other disqualifications. The first German "T-Staff" (used in May, 1915) was a mixture of xylyl and benzyl bromides. Another lachrymator was "B-Staff," or brominated methyl-ethyl-ketone, and still another was "Green T-Staff," which was a mixture of xylyl bromide and bromacetone. A high concentration of these gases produces nausea and Major Dudley has seen persons made unconscious by it.

Another class of neutralizing, as distinguished from lethal gases, is known as the sternutators, or, as they are commonly called, sneeze gases. German shells of this sort are marked with a blue cross and contain diphenylchlorarsine (a solid), mixed with a high explosive which scatters it in fine particles and causes sneezing and vomiting; the purpose being to make soldiers remove their masks and then follow up the attack with a lethal gas.

Lethal gas shells were marked with a green cross and at first contained monochlormethylchloroformate, which was "improved" by substituting trichlormethylchloroformate, sometimes mixed with phosgene, and this remains the German prime favorite. The mixture is very toxic. Sometimes it produces a delayed action so that men fall down and die a few hours after they have been gassed if they indulge in vigorous exertion.

#### THE "MUSTARD" GAS

Another discourager of irreverence toward German might and will is an eye, lung and skin irritant which bears a yellow cross upon the shells containing it, and for this reason is called mustard gas. It is a liquid that boils at over 200 deg., has low vapor pressure and is heavier than air. Mustard gas is dichlorethyl sulphide. It has but a faint, garlic-like odor and at first troops were deceived by it. To disguise the odor sometimes a little prussic acid is added and again sometimes trichlormethylchloroformate (or "diphosgene") mixed with chlorpicrin or other lachrymators. One part in 50,000

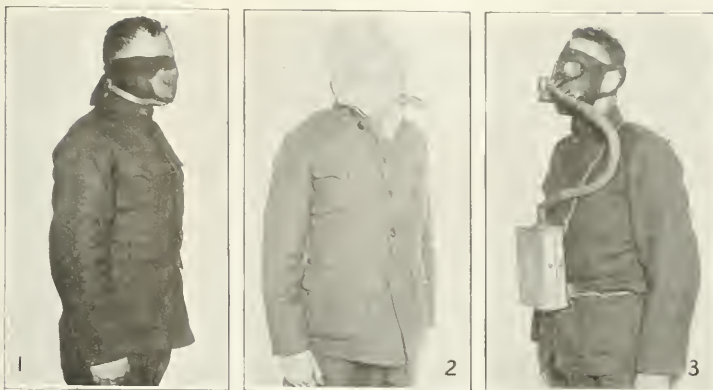


FIG. 1—A BLACK VEILING BANDAGE HOLDING ABSORBENT COTTON TREATED WITH HYPO OVER THE NOSE. (THE FIRST OFFICIAL BRITISH RESPIRATOR.) FIG. 2—THE P. H. HELMET, HAVING AN EXHALATION VALVE, THE AIR BEING FILTERED THROUGH THE MASK. FIG. 3—ORIGINAL TISSOT, HAVING A FILTER CHAMBER AIR INLET AT EYEPieces TO PREVENT FOGGING AND AN EXHALATION VALVE



FIG. 4.—BRITISH RESPIRATOR. FIG. 5—AMERICAN RESPIRATOR. FIG. 6—GERMAN LANTERN CAN RESPIRATOR

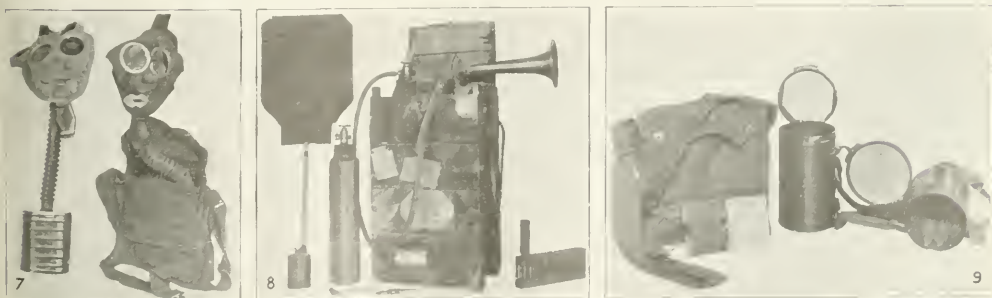


FIG. 7—AMERICAN AND ENGLISH MASKS FIG. 8—COMPRESSED AIR SIREN, HAND RATTLE AND GAS SHOVEL FIG. 9—ENGLISH, FRENCH AND GERMAN MASK PACKS



for two minutes will produce severe conjunctivitis, but this is almost the least of its evils. It is a real torture gas because, in addition to its painful effect upon the eyes, it is an intense skin poison, producing sores that easily grow septic and which are in their nature very like burns. Parts of the body that are moist with perspiration are especially susceptible to it and its effects, while not immediate, are sure and put men completely out of action. Men gassed with "mustard" are likely to be attacked under the armpits and in the crotch as well as on the hands, and the effects are exceedingly painful. Still another sequel of this poison is within the lungs, where the same kind of blistering action takes place, with pneumonia and tuberculosis frequently following. Owing to its high boiling point, if the weather is cool and calm it may cover a locality for a week or more. Sometimes again it will be apparently inactive during a cool night, but as soon as the sun

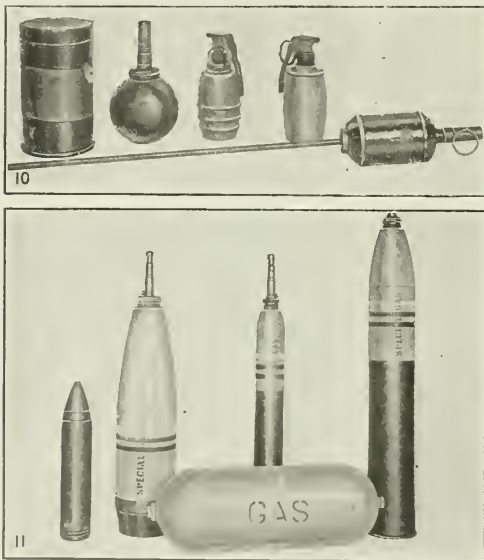
when the first attacks were made. Fighting with poison gas was one of those things that under agreement was not to be done, and the matter was considered as settled. But it wasn't. All manner of expedients were availed of at first, from handkerchiefs and socks filled with moist earth to anything else that could be thought of. The women of England and France were appealed to and provided the soldiers with respirators in the form of veils enclosing a handful of cotton wool which was dipped in a solution of sodium thiosulphate ("hypo"), sodium carbonate and glycerine immediately before using. Within three days about 1,000,000 such respirators were made in England. In the case of one British army a new respirator was devised and the women in the towns immediately behind the front were requested to make a supply. Material was rushed from Paris by every car available and within a few days those French women had provided 80,000 of the new respirators which were in use in the line of battle. The original veils were reasonably effective against chlorine, but were difficult to operate in the trenches owing to the need of keeping the soaking fluid everywhere convenient. An improvement became imperative as soon as the Germans began to use phosgene.

A respirator should be simple in design and easily adjusted. It is also important that it consist of one piece. The first improvement over the veil was the "hypo helmet," made of flannel, treated with sodium carbonate, sodium thiosulphate and glycerine in solution, and provided with mica windows. The skirt was tucked in under the collar and while it was rather unpleasant to wear it saved many thousands of lives. The next type was called the P. helmet and consisted of a bag made of (cotton) flannelette impregnated with an alkaline solution of sodium phenate. This development was made necessary by the introduction of phosgene into gas warfare. The mica goggles were unsatisfactory and were replaced with glass and a respiratory valve was added through which the breath is exhaled but through which it may not be inhaled. The protection against phosgene was later improved by adding hexamethylene tetramine to the impregnating solution. With these improvements it became known as the P.H. helmet.

#### METHODS OF PROTECTION

The introduction of inert gases made an entirely new method of protection necessary, for the flannelette filter was not adequate. This brought about the canister through which the breath is inhaled and blown out through the special valve. In the masks now in use by the British and American armies the nose must be clipped shut, and it goes without saying that the wearing of such a device for any length of time is very uncomfortable. At times, however, it has been necessary for men to wear them for as long as twelve hours at a stretch. The facepieces of rubberized cloth are made full so as to be used to wipe off the interior of the goggles, which become clouded from the wearer's breath.

Strangely enough, although the Germans were the first to use poison gas, they were not prepared to defend themselves against it when it was hurled back at them. Their masks contain a drum of charcoal screwed on before the mouth and both inhalations and exhalations are made through it. The lack of an exhalation valve is



FIGS. 10 AND 11—TYPES OF GAS CONVEYANCES. GRENADES, SHELLS AND BOMBS

shines upon it in the morning it becomes effective. It is used in enormous quantities by the German army and in all sizes of projectiles from a capacity of 300 to 400 cc. to 11 liters.

Hand grenades are in frequent use. They contain smoke producers and toxic gases for cleaning up dug-outs. It is a very useful minor weapon, and some are equipped with a device whereby a rod may be attached and the whole shot from a rifle by means of a blank cartridge. They may be called chemical ferrets and are used by the allied armies. It is much safer to throw one into a dugout than to make a personal exploration, and they have been found very persuasive among hiding boches. Later developments provide for firing gas shells of very large capacity from mortars. Gas is not used in aeroplane raids.

In regard to gas defense it should be borne in mind that there wasn't any at the beginning of the war or

a serious defect, but the drum is a clever device and has been adopted in some American and some French masks. The German facepiece was first made of rubberized cloth but later of softened leather bound with tape, and in the place of rubber bands for adjustment, cloth tubes containing wire springs were used.

## Sodium Sulphide and Other Products from Nitre Cake

By H. P. BASSETT, PH. D.

THE disposal of nitre cake, one of our large waste products in the chemical industries of this country, has for many years been a source of much investigation.

This waste product from the manufacture of nitric acid has often in the large industries, like the powder companies, been hauled out to sea and dumped, while at inland plants it is buried, when it remains for a considerable length of time, finally leaching away. These two sources of disposal are the ones generally used, as the laws of nearly all our states do not permit it being dumped into the streams, because in many cases the streams furnish water supply for cities; also, it destroys the fish in such streams.

Aside from the difficulty of disposal, there is much value lost in this material, as it contains 30 to 31 per cent free acid besides the sulphuric acid combined as normal sulphate. Of late years considerable amounts of nitre cake have been used in the glass trade and for the separation of iron and nickel, but the normal sulphate is preferred, as the acid sulphate is detrimental to the furnace linings and the free acid given off as sulphur dioxide causes damage to the vegetation.

The normal sulphate can be made from this material by neutralizing with lime and then evaporating the solution of normal sulphate, but considerable amounts of lime or limestone are required, and salt cake made in this manner is expensive and in normal times does not pay the expense incurred. However, the expense in this method may be decreased if special precaution in neutralizing, like a counter-current system, is used and the calcium sulphate obtained in a fair degree of purity, when it would have a market value as a filler for paper, in the cement industry and for many other uses where shipping facilities were adequate.

The second method is to form normal sodium sulphate and either hydrochloric or nitric acid. This can be accomplished at a temperature of red heat and a very high grade sulphate obtained if the material is very intimately mixed and a proper furnace used for carrying out the reaction.

The third method is a unique one and its commercial value would have to be determined. This method consists of mixing the nitre cake with pyrites cinder and roasting the mix at about 600 deg. C., when the free acid is evolved as sulphur trioxide, which can be absorbed in other sulphuric acid to form fuming acid, which commands a good price even in normal times. The cinder from this operation consists of iron oxide and sodium sulphate, and on leaching the sodium sulphate can be recovered.

The two last methods of course have their advantages in that the free acid is used up in making nitric or hydrochloric or sulphuric acids, which are either used

by the industries having this material for disposal or in allied industries. They have the disadvantage, however, of probably overloading the market with salt cake, and other avenues would have to be opened up for this material. This salt cake, of course, could be used in the manufacture of sodium carbonate by the Le Blanc process. But again we have a waste material—calcium sulphide—which is as bad as or even worse than the original nitre cake on account of the odor.

The problem finally develops into the disposal of the sodium sulphate or salt cake. A limited amount could be sold to the glass and nickel industries, but a very important market could be found in the sale of sodium sulphate, which can be obtained very economically from this material. This market also has the advantage of growing larger as the supplies become available. The two large uses at present are in the leather trade and in the flotation processes.

Much work has been done in this line with varying results. Berzelius obtained sodium and potassium sulphites by reduction of their sulphates in a current of hydrogen. Berthier obtained them by reduction with carbon. Many attempts have been made by Claus and others to make use of Berthier's method for the production of sodium sulphide, but unsuccessfully. In their work they obtained products which contained thio-sulphates and carbonates due to oxidation by the air in their process of manufacture. This, however, can be avoided by using carbon in the form of bituminous coal where volatile matter is given off to keep the furnace full of a reducing atmosphere and carrying the reduction out in a design of furnace which can be kept air tight. It has always been considered this reaction required a high temperature, but in my work I have found that 96 per cent of the sodium sulphate can be obtained in the form of sulphide at a temperature not to exceed 650 deg. C., which can be easily maintained in a cast- or wrought-iron tube furnace.

At high temperatures the sulphide will attack the iron or even many kinds of brick, but at this low temperature it attacks the iron only slightly, forming in time a thin black scale of an iron sulphide when the reaction ceases. This, however, will scale off if the furnace is suddenly cooled or heated, but by gradually cooling or heating the furnace, the greater part of the scale will adhere and the tube last for months for this operation. In a rotary type of furnace the tube may also be made in sections and when one section wears out it can be easily replaced. It might be of interest to state that this scale mentioned above forms only at the hottest part of the furnace, which, as stated, never exceeds 650 deg. C., consequently this section would be the only one needing replacing.

The carbon added to the sulphide is in excess of that required for the reduction, and consequently the cinder will contain some unused carbon and require leaching and crystallizing to recover the sulphide in marketable form. It might also be stated that means must be provided for cooling the material as discharged from the furnace out of contact with the air.

Other products may be made from nitre cake, as sodium sulphide and the like, but it appears to me that the manufacture of the sulphide, owing to its increasing demand, would go a long way in disposing of what now is one of the largest waste products we have.

# Nitrogen Fixation Furnaces\*—I

## A Review of the Various Types of Arc Furnaces, with Details of the Kilburn Scott 3-Phase Furnace—Balance of Current Phases, Size and Starting of Furnaces—Radiation and Cooling-Water Losses—Electrodes

BY E. KILBURN SCOTT

Arc furnaces for fixing atmospheric nitrogen differ from arc furnaces for making alloys, carbide, etc., in that instead of the electrodes being of carbon they are made of special metal which wears away very slowly. Also, the potential used is several thousand volts, which necessitates better insulation. Another difference is that air only is used or charged; the internal construction is therefore simpler as regards the refractory lining, for there is no melted metal or flux to react with or to cut the brickwork.

The furnaces are especially suited for intermittent working with off-peak power, because they can be started and stopped at any moment with almost the same facility as an ordinary arc lamp, and there is no fused material to be run off or to freeze in case the electricity fails; also, after starting up again, full yields are obtained very quickly. The furnaces may therefore be advantageously installed wherever cheap 3-phase power is available for say sixteen or twenty hours a day. The arc process is the only method for fixing atmospheric nitrogen that can be so used.

A convenient size of air nitrate factory is one to take about 10,000 kw., but of course the larger the factory the lower the cost per kilowatt of plant installed and the lower the working cost and of overhead charges per unit of finished product. The ordinary standard voltages of 5500 and 6600 and periodicities of 25 and 60 per second are suitable, so it is not necessary to install special generating machinery. The energy can be tapped from a general transmission network, although there are advantages in having the factory near to the power house.

To combine nitrogen and oxygen efficiently by electricity it is necessary to obtain as intimate contact as possible between the gases and the arcs, and various features which more closely approximate to this requirement are discussed in this paper; further, in order to emphasize certain points, comparisons are made of types of furnaces, especially those which produce the arcs in different ways. For the purpose of discussing types of furnaces, they can be classified as follows:

- (A) Designs having mechanically movable parts.
- (B) Designs employing a magnetic field to direct the arcs.
- (C) Designs depending on air currents only to direct the arc.

### DESIGNS HAVING MECHANICALLY MOVABLE PARTS

The Bradley and Lovejoy apparatus as it was installed at Niagara Falls is historical but nevertheless interesting, because it is a distinctive type. It de-

pended on the formation, prolongation and interruption of many thousands of sparks or arcs per second, each one separate from the rest. The arcs were produced by rotating an iron cylinder fitted with platinum points inside a fixed enclosing cylinder having an equal number of points. Direct current at 10,000 volts was employed, partly because the apparatus was built at a time when that form of current was generally in use. It was afterward appreciated that it would have been better to work with alternating current.

MacDougall and Howles, who were working on the problem in England about the same time, employed alternating current, and the writer gave them assistance, especially in showing how the arcs could be stabilized by reactance.

Another design depending on mechanical movement is that of J. S. Island of Toronto; see Fig. 1. There are in this furnace four V-shaped rings, two of which rotate, and the electric arc which would normally remain stationary at the shortest gap is drawn around. To the eye it looks like a ring of flame, but in reality it is a single arc rotating rapidly round the annulus. Air passes through perforations in the apices of the stationary rings, and at first sight this would appear to be a good plan. The writer's experience, however, is that such holes are subject to excessive burning.

The Rankin furnace, to which T. H. Norton draws attention in an article in the September, 1917, *Scientific American*, has been tried in California. It is a distinctive type because the arcs are mechanically caused to move through the air, instead of the air being blown through the arcs. The sparking points are fitted in a sort of piston which reciprocates in a cylinder and at the same time is rotated to and fro by a thread on the spindle. Current is led to the sparking points by wires through the hollow spindle.

As general comment on the above, the writer considers that designs depending on a number of electric sparks or arcs which are at relatively large intervals apart must necessarily allow considerable quantities of air to pass without contact. Further, designs which require constant mechanical movement of parts are obviously at a disadvantage when compared with those referred to below, which do not require moving parts.

### DESIGNS EMPLOYING A MAGNETIC FIELD

The Moscicki furnace, used in Switzerland, has a magnetic field which causes the arc to rotate around an annular opening. Referring to Fig. 2, there is a reaction chamber with an air chamber below, both of which are surrounded by water. The annular opening is formed between a high tension electrode and the lower edge of the reaction chamber, which latter is

\*A paper presented at the thirty-fourth general meeting of the American Electrochemical Society, held at Atlantic City, N. J., Sept. 30, 1918.



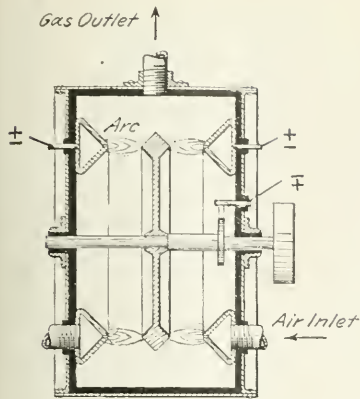


FIG. 1

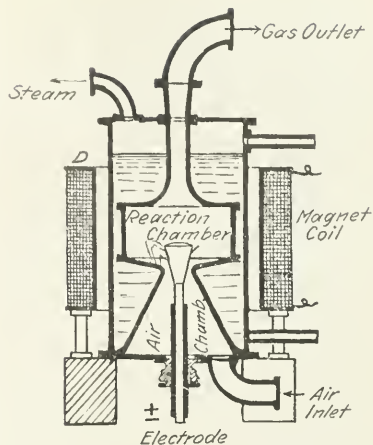


FIG. 2

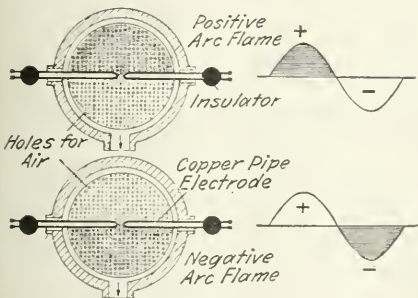


FIG. 3

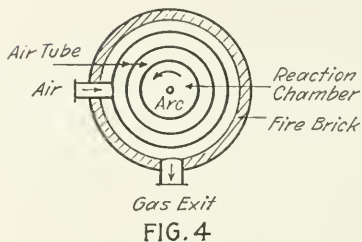


FIG. 4

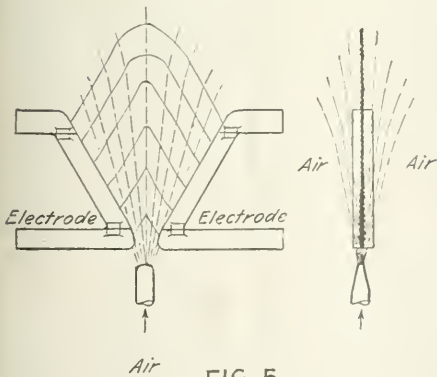


FIG. 5

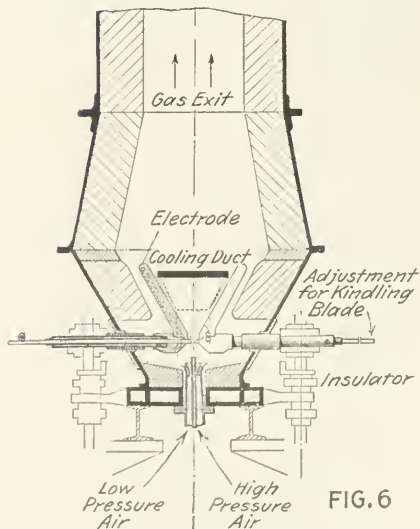


FIG. 6

FIGS. 1 TO 8

Fig. 1—The Island furnace, with mechanically rotated arc. Fig. 2—Mosevick single-phase furnace, having magnet coil to give rotation of arc. Fig. 3—Alternating arc flame of Birkeland-Eyde furnace. Fig. 4—Cross-section of reaction chamber and annular preheater tubes of Schoenherr furnace. Fig. 5—Arc flow in relation to the arc of a Pauling furnace. Fig. 6—Modification of Pauling design due to Phaecler and Heckenbleckner.

earthed. Magnet coil *D*, acting in conjunction with the steel construction of the furnace, sets up a magnetic field across the annular opening which causes the arc to rotate. It can, however, only be at one point at any one moment, whereas air passes through the whole opening all the time; it therefore follows that a large proportion cannot contact with the revolving arc.

The Birkeland-Eyde furnace, used in Norway, France and Spain, has also a magnetic field, but in this case it forces the arc into two half discs of flame, which alternately rise and break in the top half and in the bottom half of the reaction chamber. The electrodes, see Fig. 3, are of copper tubes supported on ball insulators, and they project into a circular reaction chamber, the side walls of which are pierced by a large number of small holes. Air passing through these holes strikes into the flame at right angles, and obviously at any moment only half the volume can enter on the side on which is the arc.

The arc constantly rises and breaks, and, further, many of the holes are near to the edge of the reaction chamber. A large proportion of the air, therefore, fails to make contact with the arcs. As further general comment on those furnaces which depend on a magnetic field to direct the arc, the writer is of opinion that they are at a disadvantage compared with those mentioned below, which use air only, because of the expensive magnet steel construction which interferes with accessibility, the cost of copper magnet coils and the cost of dynamo electric machinery necessary to provide direct current to excite the coils. Another reason is that an extra circuit is required, with instruments and regulating switches, etc., in order to adjust the strength of the magnetic field to suit the velocity of the air.

#### DESIGNS DEPENDING ON AIR CURRENTS

In the Schoenherr furnace, as used in Norway, air is blown tangentially into the bottom of a vertical reaction tube made of steel, and in passing upward with

is only a small fraction of an inch; therefore much of the air whirls past without coming into intimate contact with the standing arc. A point of interest in this design is that it has a special air preheater combined with it. This takes the form of annular tubes, as shown in Fig. 4, through which the hot gases and the air pass in contra-flow directions.

The Wielgolski furnace, used by the American Nitrogen Products Co. of Seattle, Wash., has also a standing arc, but instead of being similar to a single straight rod it is in the form of a "bight" having its ends springing from electrodes at the bottom. For a given voltage, the height of the arc is therefore considerably less than in a Schoenherr furnace. Each electrode is a water pipe bent into a ring and air passes up through it.

The Pauling furnace, used in Italy, Austria and Germany, has a fan-shaped arc flame which forms between horn-shaped castings. Below the electrodes

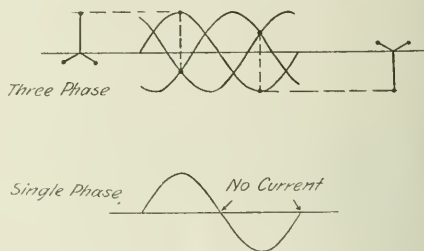


FIG. 8—COMPARATIVE CURVES OF 3-PHASE AND SINGLE-PHASE

there is an air pipe having a narrow slot, the idea being to get as much air as possible into the flame, but as a matter of fact it spreads out in all directions, as indicated in Fig. 5. Fig. 6 shows a modification installed at Nitrolee, S. C., and due to R. Phaehler and I. Heckenbleckner. Each electrode is supported at the bottom only, and the cooling water enters and leaves at that point, experience having shown that an upper connection causes short circuits and is difficult to insulate. Air is blown through two nozzles, the inner one passing a relatively small quantity at high pressure so as to cool the kindling blades. The bulk of the air, which is preheated, passes through the outer nozzle at low pressure. The power is therefore less than would be the case if all the air were at high pressure. Each side wall between the electrodes and just above the zone of maximum heating has a duct through which gases from the furnace, which have been cooled down, are blown. The object is to cool the highly heated nitric oxide below the critical temperature of dissociation, and as the return gases contain practically the same percentage of nitric oxide gas as the freshly treated gas there is no dilution.

#### THE KILBURN SCOTT FURNACE

Furnaces which work with single-phase alternating current have to be used in sets of three on a 3-phase supply, whereas the Kilburn Scott type now to be described in greater detail uses all three phases in a single reaction chamber.

As shown diagrammatically in Fig. 7, it has three wedge-shaped electrodes arranged with intervening re-

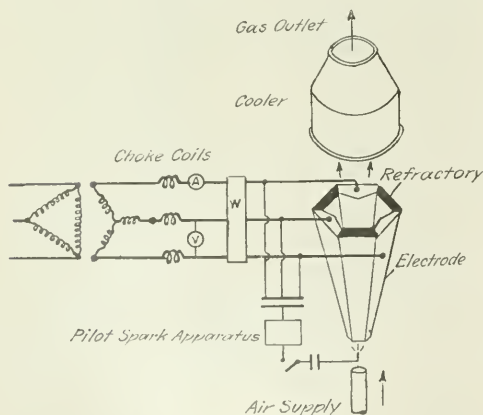


FIG. 7—DIAGRAM OF KILBURN SCOTT 3-PHASE FURNACE

a whirling motion it maintains a rod-like arc in the center. To distinguish this arc from those of other furnaces, the writer calls it a "standing arc." The cross section of the reaction tube, see Fig. 4, is about 30 sq.in. (190 sq.cm.), whereas the section of the arc

fractory material so as to enclose a 6-sided conical space, having its apex at the bottom. Three-phase current supplied to the electrodes produces a combined arc which is flared out by the air, and with 60 periods gives 360 flames per second.

By drawing three sine curves with a phase displacement of 120 degrees, as in Fig. 8, it is seen that current is always flowing in the reaction chamber, and it can be shown mathematically that the electric energy varies between 0.86 and 1.0. On the other hand, with the single phase the energy varies from zero to maximum, and twice in each cycle there is no current.

The flame appears to the eye like a double cone having one apex at the bottom, where the electrodes are nearest together, and the other at the top, where the flame tapers off. The flames flicker about with great rapidity in different planes, and so are constantly intercepting fresh particles of air. Fig. 9 indicates how it

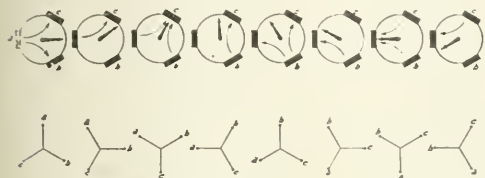


FIG. 9—DIAGRAM SHOWING ROTATION OF 3-PHASE ARC

revolves, the speed of revolution corresponding to the frequency. If we assume 60 periods per second, then as it takes longer than one-sixtieth of a second for air to pass up the reaction chamber, it follows that practically every particle must come into the arc field.

From the point of view of the supply of electric energy, it is desirable to have all three phases balanced, and this is especially necessary when current is purchased from a public supply company, for the general supply must not be affected by low power factor and unbalanced and variable loads.

When single-phase furnaces are connected to a 3-phase supply, there may be considerable lack of balance due to one furnace dropping out of circuit; also at starting up, unless all the furnaces are switched in together. If one arc fails, there is a possibility that the circuit breakers of the other furnaces may trip, with the result that a heavy load is suddenly thrown off and a surge may set up.

The 3-phase furnace gives no trouble in this way, for it functions as a single unit and the phases balance automatically. Even if deliberately set so that they do not balance, they tend to equalize by burning at those points where current is greatest. There is very little chance of a 3-phase furnace failing altogether, because the three phases help to maintain one another.

#### STARTING UP THE FURNACE

As the electrodes of nitrogen fixation furnaces are of metal and work at high voltage, they must not be brought into contact. Starting is usually effected by carefully moving the electrodes until they are near enough for current to jump across. After running until the interior has become heated, the electrodes are withdrawn to the regular working distance. Adjustment must be made carefully to minimize rush of current, and as this depends on the furnace attendant,

the amount of reactance in circuit has to be sufficient to allow for the contingency of careless operation.

The Schoenherr furnace is started by means of a lever which is moved by hand until it is near enough to the lower electrode for the current to jump across. The lever is then withdrawn and the whirling air carries the arc to the top of the reaction tube. If the arc fails, which is fairly frequent, it has to be rekindled by hand, so considerable attention is necessary.

Pauling uses the device shown in Fig. 10, which shows two furnaces connected in series in each leg of the 3-phase supply and an auxiliary transformer connected across one pair of electrodes on each series. The high tension coil of this transformer gives a voltage several times greater than the main supply, and the arcs are kept going by the higher voltage set up by current shunted through the primary coil.

While experimenting with an early model of the Kilburn Scott (K. S.) 3-phase furnace, it was found possible to use pilot or trigger sparks to break down the air dielectric and thus dispense with movement of the electrodes for starting. This is a simple solution of the problem and does away with uncertainty of operation by an attendant. A wire placed midway between the three electrodes just above the central air nozzle is connected to an extra high tension supply, which causes sparks to jump from the wire to the electrodes, thus ionizing the air and causing the main current to flow. The more pilot sparks there are in a given time the better the effect; also, the higher the frequency the less the air resistance. The two circuits work together in much the same way as when telephone and telegraph messages are carried at the same moment through one set of conductors.

With pilot sparks to break down the air dielectric between the three electrodes, the full value of the current wave is utilized and the curve approximates

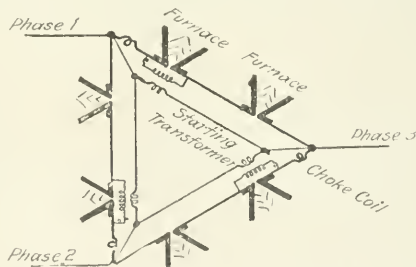


FIG. 10—PAULING FURNACES IN SERIES ON EACH PHASE AND STARTING TRANSFORMERS

to a sine wave. On the other hand, with single phase the voltage has to rise to a certain amount to overcome resistance and cause current to flow.

#### SIZE OF FURNACE

A 3-phase furnace is better than three single-phase furnaces aggregating the same power, because there is only one piece of apparatus to attend to and the cost is at least halved; also the space occupied, inclusive of passage way around the furnaces, is less.

As a 3-phase arc flame increases in three dimensions with increase of power, it follows that kilowatt capacity goes up very rapidly with increase of size. Usually



in mechanical designs doubling the linear dimensions will theoretically increase the capacity eight times, but a 3-phase furnace for nitrogen fixation increases in much greater ratio.

Speaking generally, the larger a furnace the more accessible are the interior parts and the easier it is to adjust and renew the electrodes. Radiation losses are also relatively smaller, and the percentage of energy absorbed by the reactance coils being less, the power factor tends to be higher.

The Schoenherr design is limited to about 1000 kw., because the length of the reaction tube is governed by the voltage, while at the same time the current that can be dealt with from a single electrode is limited.

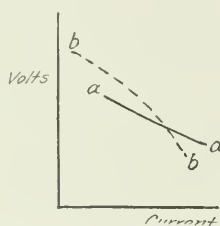


FIG. 11—CHARACTERISTICS OF ARC AND ALTERNATOR

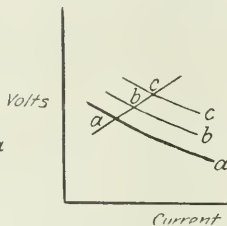


FIG. 12—FALLING AND RISING CHARACTERISTICS OF ELECTRIC ARCS

Again, the amount of air that can be passed through a reaction tube at a given velocity is limited, so in order to increase output a larger diameter tube would have to be used, thus giving greater clearance around the arc.

Birkeland-Eyde furnaces are now built with a capacity of 4000 kw., which is about 20 times larger than those made some twelve years ago. They are essentially a single-phase design. During the same period, carbon-arc furnaces for making alloys and for carbide have increased in a much greater ratio, and they are all now made for multi-phase working.

#### RADIATION AND COOLING-WATER LOSSES

In the Schoenherr furnace, radiation accounts for 17 per cent and the electrode cooling-water for about 30 per cent. It is therefore desirable to design electric furnaces with as small radiation surface as possible and with a minimum of electrodes through which heat can pass to the outside air.

Radiation loss varies directly as the wall area of the furnace, and cooling-water loss may be said to vary with the number and the size of the electrodes. Two electrodes being the least that can be used for any one furnace, it follows that three single-phase furnaces must have six electrodes while a 3-phase furnace of the same total power has only three.

Three electric arc flames acting together in one closed space will give a higher average temperature than the same arcs each at some distance apart and within separate walls each radiating heat. That is to say, a 3-phase furnace of 3000 kw. will have less wall area and therefore less radiation than three 1000-kw. single-phase furnaces; also the heat absorbed in cooling three electrodes of one furnace will be less than for cooling six electrodes of three separate single-phase furnaces.

Doubling the number of electrodes means doubling the pipe connections and fittings, also electric cables,

etc.; and as the water connections must necessarily be connected to the high tension supply, it is an advantage on this account to have as few as possible.

In furnaces with diverging electrodes, heat is principally generated about one-third the way from the bottom, so the cold water should impinge at about that point in order to keep the metal from being worn too rapidly. At the same time, in order not to reduce the temperature of the reaction chamber too much, it is necessary to adjust carefully the amount of cooling water.

#### ELECTRODES

The writer's conception of a blown-arc flame is that it consists of arc threads or streamers, which strike across the bottom of the electrodes and then, acting like flexible conductors, are carried up by the air current. The ends move rapidly over the surface of the electrodes until the arcs have reached the maximum length at which the voltage will sustain them, when they snap suddenly and new arcs are started.

If the formations and extinctions of the arc threads synchronize exactly with the alternations of the electric current, then the furnace is working smoothly, and it is easy for those accustomed to such furnaces to know this by the sound.

Around each arc thread there is a flame of burning nitrogen, and as nitric acid forms it diffuses away into surrounding air and in so doing becomes cooled. Probably the quickest chilling takes place at the moment when each arc-thread breaks. The arc also tears particles of metal from the electrodes, and these, becoming

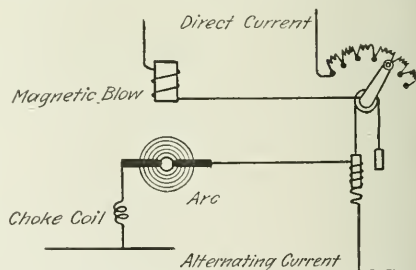


FIG. 13—DEVICE FOR STABILIZING THE ARCS OF BIRKELAND-EYDE FURNACE

incandescent and oxidized, may play some part in expediting or retarding the reaction, for it is known that some metals are better than others from the point of view of yield of nitric oxide.

With diverging electrodes, the ends of the arcs travel along the surfaces in leaps, which is possibly due to softening of the metal, and the arc is momentarily held at each point until pressure of air (or the magnetism in the Birkeland-Eyde furnace) overcomes the adhesive tendency. When the surfaces of electrodes are large, the wear is relatively slow and the electrodes need renewal only at long intervals. On the other hand, when the arcs spring from the end of an electrode, as in a Schoenherr furnace, burning is intensive and the electrode has to be fed forward regularly.

The electrodes must be of dense metal having high melting point and not readily oxidized; also it should be a good heat conductor so as to pass heat quickly to

the cooling water. Steel is used in the Schoenherr and Moscicki furnaces, but it is not a good metal because the magnetic oxide of iron to which it burns may be carried over to the absorption towers and stain the acid. Steel begins to oxidize at about 370 deg. C., and oxidizes rapidly at about 500 deg. C. Nickel has an ignition temperature of about 650 deg. C., but it is too expensive to use, and this remark also applies to many metals and materials which have high melting points—platinum, for instance. Those working on the nitrogen fixation problem are always on the lookout for better electrodes.

In this connection, the process called "calorizing" is of interest, because it raises the oxidizing temperature. The process depends on the fact that at high temperature and in a neutral atmosphere powdered aluminium will enter into combination with a metal and form a homogeneous alloy which cannot be destroyed except as part of the mass of which it is part. Depth of the impregnation depends on the length of time of treatment, and by it the oxidizing temperature of steel can be raised to over 1000 deg. C.

Copper is a good metal to use for electrodes, because it is easily made to the required shape and wears away smoothly without releasing troublesome vapors. After a run with some copper electrodes which were fixed by steel screws, having their countersunk heads in line with the path of the flame, it was noted that the steel was considerably burnt, whereas the surrounding copper had only slight surface marks.

It is important to minimize the oxidation, because when a considerable amount of electric energy is employed in vaporizing metal, then there is so much less energy for exciting the gas molecules and bringing about the nitric oxide reaction.

Birkeland-Eyde furnaces use tubes of pure electrolytic copper about 2 in. (5 cm.) in diameter and  $\frac{3}{16}$  in. (5 mm.) thick, bent into the form of a U, each leg of which is about 8 ft. (2.4 m.) long.

Electrodes of copper alloyed with other metals have been used to advantage, and those metals which show good nitrogen bands in the arc spectrum are obviously the better ones to employ.

There is some reason to suppose that the presence of metals or oxides of metals act in a catalytic way in increasing the velocity of the reaction. The action of a catalyst is supposed to be such as to make it unnecessary to use higher temperature to get a workable velocity.

For smooth electrical operation it is important to have the arc stabilized, and this is the condition which gives good yields of nitric oxide. Further, it is important to have the furnace working easily, because of the effect of an unstabilized arc on the supply circuit. An ordinary arc lamp works well, because the carbons are automatically moved so that the distance between them increases with current, to effect which an electro-mechanical device is used. This is possible because the parts to be moved are small and of light weight, but obviously the heavy metal electrodes of large electric furnaces and the large power involved present a much more difficult problem.

The resistance of an alternating arc varies with current in such a way that when the voltage between the electrode decreases the current then increases. In

other words, the characteristic of the arc is a falling one, as shown by curve *aa* of Fig. 11. If the voltage of supply can be made to fall in accordance with the arc characteristic, then complete stability of the arc is obtained, but to do this the only way is to specially design the alternator for a large voltage drop, as shown by curve *bb*. The writer has used such an alternator with good effect, and it is of interest to note that the latest installation in Norway, at Rjukan II, has alternators with large voltage drop, each supplying a group of three single-phase furnaces of 4000 kw.

When an air nitrate factory receives energy from a transmission line so that step-down transformers are required to reduce the voltage to that required by the furnaces, then reactance may be embodied in the transformer. The transmission line itself and the various connections, etc., also give some reactance, which goes toward reducing that necessary in the separate reactor.

It is obviously desirable to design a furnace so as to work with as little reactance as possible, and one way is so to design the electrodes that they require little or no adjustment, for obviously reactance must be larger if the contingency of inexpert adjustment has to be met.

Stabilizing an arc against what may be called abnormal conditions may be done by automatically varying the force of the air in accordance with current in the arc, for increased air pressure increases the arc voltage. With varying air pressures the arc characteristic will move out parallel to itself, as shown in curves *bb* and *cc* of Fig. 12. An automatic device may be employed to do this, so giving the equivalent of a rising characteristic, as shown by the curve *a*, *b* and *c*.

F. G. Lilienroth has suggested such a device, and for a Birkeland-Eyde furnace (see Fig. 13) he provides a regulating switch in the field-magnet circuit, which switch is varied by a solenoid through which passes the current of the electrodes.

(To be concluded)

### Restoration of Belgium

At a recent meeting of the New York Section of the Society of Chemical Industry a resolution, introduced by Dr. Jerome Alexander, was passed which, after reciting that Germany had deliberately stolen, destroyed or carried away machinery and property in occupied territory and had deported or destroyed communities of skilled artisans, all for the purpose of permanent economic injury of competitors in the world markets, read as follows:

*Be It Resolved*, That the New York Section of the Society of Chemical Industry requests that the proper authorities of the various allied Governments take special note of the above facts and insist that Germany, where possible, be compelled to restore the stolen machinery and other property, or replace the stolen property and also whatever machinery or property has been destroyed, by equivalent machinery or property taken from German factories; and that they furthermore see to it that all allied industries are fairly and justly safeguarded under the ultimate terms of peace against the machinations of an insidious and conscienceless enemy, whose express intention is to reduce other nations to industrial subservience and dependence.

## Future of Pure and Applied Chemistry\*

Account of the Political Aspects of Chemical Science in the British Empire — Retrospect on Conditions Prevailing at the Start of the War and the Sudden Changes That Were Brought About Thereby

By WILLIAM JACKSON POPE

FOR THREE years pure chemical research has been dormant the whole world over, and it would be difficult for the most accomplished essayist to arrest attention for an hour by an address on a subject of purely academic interest. Our mental point of view and our outlook upon both present and future are entirely different from those of four years ago; although the present is obscure and painful, the future gives promise of brilliant and rapid developments in natural science in general and in chemistry in particular. In this belief I venture to lay before you some reflections upon the growing recognition of the importance of our science and upon the responsibilities with which, owing to this change in public opinion, our shoulders are laden.

I have often heard the statement made by men who have grown old in the service of science that chemistry, and particularly applied organic chemistry, is a subject in which the British nation can never excel; that minute attention to detail, coupled with the power of organization and coöperation, entails something antipathetic to the British character; the Germans, we know, have often expressed this view. The events of the last three years have sufficed to dissipate this fallacy forever. The manner in which Great Britain, caught in the autumn of 1914 with scarcely any resources in the shape of equipment for the manufacture of fine organic chemicals, has rapidly become a larger producer of explosives, pharmaceutical, photographic and other essential chemicals than Germany will remain an enigma to the historian of these present times. The obscurity which surrounds this rapidly executed operation is not diminished by the existence of difficulties which have naturally acted as inhibiting agents.

This country enjoys in a greater measure than other states a representative government, and, in spite of the many advantages of such a form of government, the fact remains that it necessarily admits of no representation of any phase of public opinion not loudly and insistently expressed. Science has always been in this latter position; it has been unvocative. During the first few years of the nineteenth century, Dalton enunciated the atomic theory, Thomas Young stated the undulatory theory of light and James Watt invented the steam engine, and by these events all the amenities of human life have been revolutionized; indeed, they have exercised vastly more influence on the well-being of our race than did the Napoleonic wars. So accustomed are we, however, to routine habits of thought that most of us would probably answer, in reply to a suddenly posed question,

that the battle of Trafalgar was the most pregnant event of the first quarter of the nineteenth century.

### THE POLITICAL POSITION OF CHEMISTRY

A brief moment of reflection would lead us to correct this hasty statement. Sodium was discovered by Davy in 1807, and benzene by Faraday in 1823. From sodium we obtain sodamide, the prime agent in making artificial indigo an economic possibility; the separation of benzene from coal-tar led by logical sequence to the production of Perkin's mauve and of thousands of other synthetic coloring matters, and to the manufacture from coal-tar anthracene of synthetic alizarin, the first heavy blow aimed at the position of the Turkish Empire, involving as it did the ruin of the Turkey-red or madder industry. The first practical process for making aluminium depended on the use of Davy's sodium, and with the aid of Davy's safety-lamp 250,000,000 tons of coal are mined annually in this country with comparatively slight risk. Faraday's early investigations on the chemical aspects of electrolysis and his studies on magnetic induction led immediately to the invention of the dynamo, and, through Clerk Maxwell, to the introduction of wireless telegraphy; this one branch of Faraday's investigations, in point of fact, constitutes the ground-work of the whole stupendous vista of results of the general introduction of the electric current into modern life which is so familiar to us all. Cavendish's early production of nitric acid by the passage of an electric spark through air, reproduced on an enormously larger scale, is now furnishing Central Europe with the nitric acid without which no explosives could be manufactured.

Any one who is in the habit of reading modern historical writers—and they have become quite illuminating since a scientific mode of writing history has been substituted for the older fictional style—knows how political changes, national reforms arising from an effort of the collective conscience, the magnetic influence of some popular demagogue, and the like, are invariably invoked as explanatory of all the vicissitudes of our planet.

The modern historian is here taking a false point of view, and since he is, in general, quite unacquainted with physical science, his methods are inadequate. The whole history of Europe for the last century has been made within a few hundred yards of Burlington House in our scientific laboratories. One of the most potent incentives to political changes resides in the desire to increase the amenities of life, and research in pure science has had for a hundred years past the greatest influence in facilitating the realization of that desire.

\*Abstract of the presidential address delivered at the Annual General Meeting of the Chemical Society, March 21, 1918, in London.



Coöperative effort, one of the most striking aspects of modern life, only became possible when science provided the facilities for municipal power schemes, for telegraphic connection over the whole world, and for the concentration of production in definite centers. Chemical science is still furnishing the means for further revolutionary changes; during the last few years we have seen great technical developments of purely scientific discoveries—the work of Dewar on the liquefaction of gases, and that of Cross and Bevan on viscose and artificial silk, both of which have led to the profitable utilization of vast amounts of capital—and it is as yet impossible to indicate the ameliorations of the conditions of human life which will inevitably result from contemporary chemical investigation.

In a time of crisis like the present, British custom tends toward the replacement of unreal conventions by what is really vital; we have been engaged upon this operation for several years. While previously unheard-of changes have succeeded each other kaleidoscopically in the national constitution, in the political parties in power, in the freedom of the subject and in hosts of other ways, the nation has recognized that science is the only real maker of history. The whole empire is now one vast chemical and engineering laboratory, and we even live on a scientific ration of so many calorific units. It is obvious that chemistry, with physics, engineering, preventive medicine and others of the natural sciences, which previously had no imperialistic position, because powerless to make or break a Government, have become the pivot on which turn all our hopes of retaining an independent national existence; it has been suddenly realized that supremacy in these branches of knowledge is vital to our country.

#### THE POSITION OF SCIENTISTS IN THE STATE

The time is approaching when this state of affairs will change; neglect of the natural sciences will then no longer put us in danger of sudden extinction, but, as was taking place years ago, will lead to our slow, certain downfall as a nation. The responsibility is placed upon our scientific men of taking such measures as will insure that the old order is not re-established, that science makes her voice heard in our national councils and that policies of drift are forever abandoned.

We have in this country three large and long-established organizations devoted to various phases of chemical science: the Chemical Society, the Society of Chemical Industry and the Institute of Chemistry. It is too much to ask that these three representative bodies, with perhaps the newly-founded Association of British Chemical Manufacturers and ultimately all the other cognate but more specialized interests, should set up a watchful and alert joint council with directions to consider national questions in which any of the varied interests of chemistry are concerned and to make such representations to our administrators as would voice the corporate view of the joint body.

I am inclined to think that, had such a body been in existence several years ago, much that has been accomplished in the interval by somewhat devious methods would have been better done. One instance will occur to every one: that of the much-debated question of the re-

establishment of the coal-tar color industry in Great Britain. The scheme adopted by the Government for resuscitating this phoenix in our country, after its past thirty years of profligate productivity on the Continent, was launched without scientific advice; the Cabinet mouthpiece, indeed, declared that the directorate of the company was not to include men of scientific knowledge, on the ground that a director who knew something about the business of the company would have an advantage over his less well-informed colleagues.

Owing largely to the fact that we possess no strong collective council, representing the combined academic, scientific and industrial aspects of our science and capable of representing them before a representative Government, it may be argued that we chemists are not altogether blameless for the particularly blundering way in which particular errors have been perpetuated by the responsible officials. While we should be thankful that our blunders have not led to our destruction, we should proceed without further delay so to organize the resources of chemistry as to make it possible to enforce the adoption of scientific methods and modes of thought by authorities to whom these are yet strange.

The serious character of the British position in connection with the coal-tar color industry becomes more evident when one considers that this is a key industry; upon it depend the textile, paper, photographic and pharmaceutical industries. The total capital employed in the organic dye industry in Great Britain is between four and five million pounds, while the capitalization of the German coal-tar color firms is of the order of fifty million pounds. The need for greater and more intelligent activity in this direction is obvious; unless national enterprise can be stimulated into providing adequately for the manifold requirements of Great Britain and her colonies in all those industries which depend on coal-tar color manufacture, we shall be again in the hands of the foreign producer.

The control of a national dye scheme by business men with no real feeling for the enterprise on which they are engaged renders it fairly certain that the wider aspects of coal-tar color manufacture will be neglected. The interweaving of the color interests with those of synthetic pharmaceutical, photographic and other chemical industries is essential to success. The utilization and development of the resources of the empire in natural coloring matters such as indigo is necessary from a national point of view. The careful study of our own and other codes of patent law in their bearings upon the fine chemical industry is also important. These weighty questions cannot receive adequate consideration from any purely lay body. It is mournful but instructive to compare our present position in the coal-tar industry with the prospects which that branch of applied chemistry exhibited to Great Britain in early days. The first coal-tar color was made by Perkin in 1856, and in 1862 Prof. A. W. von Hofmann, one of the foremost chemists of the day, a German, domiciled in this country, painted an alluring picture of the future in store for us. Said he: "England will, beyond question, at no distant day become herself the greatest color-producing country in the world, nay, by the strangest of revolutions, she may ere long send her coal-derived blues to indigo-growing India, her tar-distilled crimsons to coch-

ineal-producing Mexico, etc." When we contrast this dazzling prospect, made by one of the most far-sighted of contemporary German chemists, with the actual situation, we cannot but ask why the event fell so miserably behind the forecast.

### THE MODERN EDUCATION

The reason, in my opinion, lies in the fact that opulent, indolent Great Britain has for the past century permitted all its educational interests to pass into the hands of a particular caste which despises all knowledge difficult to attain, and, to camouflage its own idleness, has always pressed the notion that a first-hand knowledge of the facts of natural science and the conclusions to be drawn therefrom is unimportant, and that the young man or young woman does his or her best in the world if thrown into it entirely destitute of anything but an evanescent acquaintance with certain classics and a decided taste for so-called learned leisure. The greater among the ancients were creators of new knowledge as well as masters of the whole accumulated world's stock of information; their successors, unproductive of positive knowledge and very ignorant of the great changes taking place around them, can but wonder at and comment vaguely on the genius of Archimedes and Aristotle, and necessarily despise the achievements of Newton and Kelvin, their modern prototypes. Illustrations of the stultifying effect of a purely classical education are laid before us every day; one recent example may be quoted here. The gentleman who shares with Mr. A. J. Balfour the honor of representing in Parliament the greatest center of business and financial activity in the world made the following statement in the House of Commons recently while opposing Mr. Fisher's Education Bill: "It was said that education was necessary to make the rising generation good business men. His experience in the City was that the man who took Firsts at Oxford generally came out last, and that the man who could hardly write his name generally came out first. The explanation was that education could not put into a man that instinct of self-preservation and common sense which was the foundation of all success in business. How could education assist a farm laborer to spread manure on a field? The best laborer he had known was wholly illiterate. If the waste of the war was to be replaced, it would be necessary for the young to start as early as possible in doing a day's work, instead of wasting time on useless book learning." This representative of the City of London is a baronet of recent creation and a director of one of the largest London banks and one of the most important English railroads; he received his "education" at one of the oldest and most rigidly classical of our great public schools. Comment is probably unnecessary.

Every scientific man in the world realizes that an innate appreciation for fine literature, for great thoughts nobly expressed and for the appropriate delineation of our greatest aspirations are among the most sublime instincts of humanity and demand the most careful cultivation. Our literary men say that we cannot express ourselves effectively, and offer as a satisfying feast the old bones left us by the Greeks and Latins, chewed over for centuries until so devoid of nutriment that they led ultimately to the mental atrophy which characterized

the Middle Ages, an atrophy that was only shaken off by the taste for knowledge which arose from the exploits of geographical science in the Elizabethan period.

If the power of expression rests with our literary friends, why are they so idle? It is their obvious duty to devote themselves to popularizing the natural knowledge acquired by the scientific observers of the past two centuries; this real learning has so infinitely extended human interest in the world around us and gives such promise of further conquests that an appeal for its consideration would certainly not have been made in vain to Plato or Lucretius. No one asks for the abolition of classical literary learning, but the whole world is now demanding that the young should be provided with an education which includes an insight into our present-day knowledge of the universe.

The rather petty disputes which rage about this matter of classical and scientific education are one-sided; the scientific man generally knows something of both aspects of the subject, while his classical compeer rarely has any acquaintance with science. Unfortunately, the great questions involved have more than a petty bearing upon the well-being of our nation. The classical school has held our country in such bondage that, to all practical intent, no person can be admitted to the higher public service unless he swear adhesion to the caste. It is almost regarded as a platitude that acquaintance with natural science disables a man from fulfilling any high public office; practically all the superior positions in the Civil and Diplomatic Services must be filled by men of classical instincts.

### TRAINED MEN FOR GOVERNMENT STAFFS

I venture to think that the wisdom of this mode of selection has been seriously impugned during the last four years. The huge Government departments which have arisen of late may be divided roughly into two classes—those staffed by men of some scientific training and those staffed by classical university graduates. Any one who has had occasion to note the numerous recent criticisms on Government departments must have observed that these strictures have almost invariably been passed on administrative branches of the service: delay, the encumbrance of red-tape and inability to draw a decision seem indigenous in certain Government offices, and none of the numerous attempts at reform has been successful. The administrative services are those in which the classical man is predominant. Other branches, such as the home Army Medical Service, have practically never been charged with inefficiency; the worst that has been alleged is a suggestion of extravagance.

The department just named is staffed by men who have had at least the rudiments of a scientific education; if control in the Royal Army Medical Service had been vested in the classical scholar of ability but no knowledge, it is certain that the last three years would have seen a repetition of the Crimean campaign horrors and that the army mortality from disease would have been greater than that caused by the instruments of war.

Such a control, happily, has been avoided; it has been avoided merely because medicine possesses the collective organization for which I plead in chemistry, an organization so strong as to make the imposition of an irresponsible lay control unthinkable.



I have already directed attention to the frequently expressed opinion that, as a nation, we are incapable of excelling in the fine organic chemical industry; let me quote one instance, small in itself, but large in its consequences, in disproof of this view.

The ordinary photographic plate is sensitive only to a region in the blue of the spectrum, but by incorporating certain rather fugitive organic dyes with the sensitive film, the latter may be rendered sensitive to the green, yellow and red parts of the spectrum; photographic plates so treated are described as panchromatic. The quantities of the sensitizing dyes required for the whole world's consumption in normal times is minute, being, indeed, of the order of a few pounds per annum. Until 1915 these substances had never been made outside Central Europe, and little was known by us of their compositions or of the methods of preparing them, as they were all sold under trade names. The manufacture of these materials, small as was the whole business, had been industriously cultivated by the German color works, and, as these color sensitizers are essential in aerial photography, their scarcity became of serious import quite early in the war.

The experimental investigation of the whole subject was quickly put in hand in this country, and within a few months ample supplies of the usual sensitizers were produced. Further, the newly established Department of Scientific and Industrial Research financed the development of the study of photographic sensitizers; as a result of this action new sensitizing dyes have been produced which are far superior to the older ones. It is safe to assert that the manufacture of panchromatic plates has now attained a degree of perfection in this country such as will long defy competition.

This is but one case that may be quoted from among a host of others, all of which prove conclusively that, given a little encouragement and assistance, British chemistry is capable, not only of giving much needed relief in this time of strain, but of meeting every demand which can be made on it when the period of reconstruction commences.

While the absence of the powerful weapon provided by a collective chemical council, embracing all interests of the science, has made it impossible for us to render the most economical service to our country, it is perhaps satisfactory to reflect that hitherto all that has been sacrificed is economy. Our lack of power to enforce our views has led to financial extravagance on the part of the authorities; the lack of economy in time, which means lives, cannot be attributed to our chemists. The duty will fall to some future President at some later time to record the spontaneity with which the Fellows of this Society volunteered for service in our chemical works, our munition factories and with the Colors either in our gas service or elsewhere.

One aspect of this question, however, calls loudly for attention. For several years past our teaching staffs have been depleted, and but a small fraction of the normal number of young men have been able to present themselves for training in chemistry. While the present demand for capable young chemists is vastly in excess of the supply, an even more serious situation awaits us in the future. If hostilities were to cease tomorrow, five years would be needed before our colleges and universi-

ties could begin to supply the large numbers of young chemists which will be required for the development of the future great fine chemical industry of this country.

Surely this is a matter which should engage the serious attention of the country. If it prove necessary to import young chemists from neutral nations to man our reconstruction schemes, a handicap will be established which we may never outrun. The adoption of some scheme by which a sufficient number of juniors can be provided to help in the great developments which the future has in store for the scientific industries of the country is of the utmost importance.

#### THE VALUE OF CENTRALIZED ORGANIZATION

It is impossible to reflect on the desirability of a closer coöperation between the large societies representing chemistry in Great Britain without foreseeing many directions in which such a union would be of value. As in every time of awakening, there exists at present a great feeling of unrest among the younger members of our profession; of late quite a number of propositions for the formation of new scientific societies have been promulgated, and all for the purpose of placing more power in younger hands and for insuring to the juniors more security of advancement. The final objects of these propositions, so far as I have understood them, are entirely praiseworthy, but it is to be feared that the methods suggested for their attainment are not always such as appeal to older and more experienced people as likely to prove successful. If we chemists collectively were in possession of some more centralized organization, such a one, for example, as is represented by the Chemists' Club in New York, with facilities for hospitality, meetings, library, laboratory accommodation and the like, no question could ever arise of the creation of a new chemical body unconnected with the main organization. A new and vigorous issue of the parent organization would shoot at appropriate intervals, and would remain contributing to the strength of the family under the original patriarchal roof. We greatly need a central home of all the chemical interests in the country, and premises, several times as large as the Chemical Society rooms, to use as a club, of which every chemist in the country would be a member. The question of the necessary expansion of the library, which is occupying the earnest attention of your Council, would find an easy solution in such a pooling of interests.

Notwithstanding that during the past forty years much has been done to facilitate the entrance of talented and promising young men into the scientific professions, far more progress must be made in this direction if we are to regain for Great Britain the paramount position she once held in scientific discovery. The Natural Science Departments in every university in the country call for expansion in personnel, laboratory space and equipment, and in provision for post-graduate research work; while scholarships for students in training are fairly plentiful, the difficulties which face the advanced student who needs to spend and who would benefit immensely by spending several years on original research are often insurmountable. Every professor of chemistry in the country can recall many instances in which he has had to send his students into technical life at too early a period, simply because it



has been impossible to secure for a good man the £150 to £200 per annum necessary for living expenses; the provision of this small sum would, in many cases, convert a half-trained chemist into a far greater asset to the state.

While a collective effort, exerted by all the interested branches of our science, to insure the efficiency of the newly-established organizations for furnishing the requisite relief is urgently desirable, it should be noted that it will become increasingly difficult to retain students capable of taking leading positions for a sufficient time to insure their proper training. During several years past I have been visited by gentlemen representing large chemical industries who have walked around my research laboratories to sort out the workers and to make overtures to such as they judged suitable for their own work; the pressure thus exerted upon the universities to force the premature delivery to the work of the best men they have in training will necessarily increase with the coming still greater demand for technical chemists.

#### GREATER REMUNERATION NEEDED

The intellectual professions may be roughly classified in two categories: the productive and the parasitic. Those of the productive class, which include all scientific workers who produce new knowledge, are, in general, poorly remunerated; their practitioners are ordinarily so intensely held by the interest of the work in hand that they have little inclination to divert their energies to the necessary extraction of higher emoluments. The parasitic class, on the other hand, have always been able to command ample remuneration for their labors; the reasons for this difference are various, and need not now be detailed. It may be noted, however, that at the jubilee of this Society in 1891 the veteran, Sir W. R. Grove, who in his young days did so much to develop chemical science, told us that he was led very reluctantly to desert chemistry for the law because "the necessities of a then large family gradually forced me to follow a more lucrative pursuit." The autobiography of the late Lord Playfair tells a precisely similar tale. Neither of these men is now remembered by anything beyond the great achievements in chemical science of his early days.

The fact emerges that if science is to retain in its service such a proportion of the most powerful intellectual and creative talent of the empire as will suffice for our progress as a nation, some method must be devised for securing to its followers appropriate emoluments commensurate with those now allocated to the non-productive professions.

This is not only necessary in connection with those purely utilitarian branches of chemical science to which I have already directed attention, perhaps too insistently, for illustrative purposes. A great danger exists at present, and will grow in the future, that the enormous productiveness of experimental science will overshadow the importance of scientific work of less immediate utility. It would be a great calamity if pure science were neglected in favor of the cultivation only of natural knowledge which gave immediate promise of beneficial material results. One of the most important functions of any expression of collective chemical in-

terest such as I have foreshadowed would be to insure that pure unproductive scientific research should be retained on an even higher level than that assigned to immediately productive original investigation.

At the present time physics and chemistry are merging into one; we foresee that the near future will furnish us with still broader views of the universe and will mark a new development more illuminating even than the great advances which followed Dalton's atomic theory and all its nineteenth century sequences. No material interests must be allowed to check this stupendous expansion of our knowledge.

**Hardness of Ingot Iron and Copper:—**F. C. KELLEY in the October, 1918, issue of the *General Electric Review* studies the hardness of ingot iron with a view of producing metal capable of replacing commercial copper where the latter is used merely on account of its softness. The iron tested contained

|    |       |
|----|-------|
| C  | 0.05  |
| Mn | 0.02  |
| Si | trace |
| S  | 0.010 |
| P  | 0.004 |

The results of the Brinell hardness tests are tabulated below:

| Iron                                                                            |       | Copper                                                     |      |
|---------------------------------------------------------------------------------|-------|------------------------------------------------------------|------|
| 1. Unannealed sheet bar.                                                        | 96.4  | Unannealed bar                                             | 80.7 |
| 2. Annealed at 770 deg. C. for 8 hours in closed pot                            | 79.7  | Annealed at 600 deg. C. to dead soft state in gas furnace. | 40.4 |
| 3. Unannealed bar cold rolled, $\frac{1}{2}$ reduction                          | 111.5 | Unannealed bar cold hammered, $\frac{1}{2}$ reduction      | 91.0 |
| 4. Sample 2 reannealed in pure hydrogen (Ruder's Anneal) 3 hours at 923 deg. C. | 60.4  |                                                            |      |
| 5. Ruder's Anneal on sample 1.                                                  | 61.6  |                                                            |      |
| 6. Annealed 2 hours in Arsen vacuum furnace at 1000 deg. C.                     | 64.0  |                                                            |      |
| 7. Sample 4 cold rolled, $\frac{1}{2}$ reduction                                | 95.7  | Sample 2 cold rolled, $\frac{1}{2}$ reduction              | 91.0 |

**Behavior of Iron Compounds at Extremely High Temperatures:—**Following studies of the spectra of iron and its compounds in flames and furnaces, G. A. HEMSALECH (*Philosophical Magazine*, Vol. 36, p. 209) concludes that the iron atom is not permanently detached from its compounds by the action of heat. He used a resistance furnace consisting of a heat-insulated carbon tube 14 mm. internal diameter, 3 mm. thick and 6 in. long, clamped between heavy graphite terminals. The iron spectrum appeared in the furnace from 1500 deg. C. to 2400 deg. C. whether metallic iron was present or not, and corresponded to that given by any iron compound fed to the cooler of the following flames:

|                                | Deg. C. |
|--------------------------------|---------|
| Air-coal gas (cone), less than | 1700    |
| Air-coal gas (mantle)          | 1850    |
| Oxy-coal gas                   | 2450    |
| Oxy-hydrogen                   | 2550    |
| Oxy-acetylene                  | 2700    |

The spectrum is restricted at lower temperatures. At about 2500 deg. C., the boiling point of iron, a general change in the character of the spectrum occurs.

From the evidence the author concludes that the furnace- and flame-spectra up to about 2500 deg. C. are caused by the partial dissociation of compounds due to heat, and while the orbital motions of its components are changed, the compound retains its individuality throughout. On the other hand, in the explosion region of the air-coal gas flame the iron atom, thanks to its strong affinity for nitrogen, is free during the time necessary to change into a nitride, and the spectrum of this flame shows a high degree of development comparable to that observed in the arc and spark.

# Metallurgical Practice on Cinnabar at Idria, Austria\*

A Description of the Plant Installation and the Types of Furnaces in Use,  
Including Shaft, Cermak and Kroupa Furnaces—Condensation of  
Mercury—Soot Treatment—Production

BY DR. ROLAND STERNER-RAINER

**I**DRIAN quicksilver operations have withstood the vicissitudes of troubled times for over five centuries. The story of Idria's past has been related to us by conscientious historians, who have shown not only the influence of the world's affairs on its prosperity and development but also the development of its metallurgical practice.<sup>1</sup> In the following will be described not only the current practice but also the improvements which are planned for the near future based upon recent experiments.

The Idrian ore body is associated with the conglomerates and the typically Idrian "Skonzaschichten" (black, bituminous slates and sandstones interbedded in the Wengenschichten, carrying fossil plants) of the upper Triassic and with dolomite breccias, dolomites and the Guttensteiner limestones of the lower Triassic.<sup>2</sup>

The broken ore, which is hand-sorted in the mine into plus and minus 2 per cent material, is transported to the ore-dressing plant (Fig. 1.) in cars having a capacity of 700 kg.

## CRUSHING AND SIZING PLANT

The ore is dumped on a 90-mm. vibrating screen (Seltner patent). The plus 90-mm. material passes to a rock crusher, which discharges on another screen, the fines of which constitute the so-called "armer Erzgries" or low-grade fines. The coarse material is fed to a circular rotating sorting table, from which high-grade ore and material to be recrushed is picked out. This high-grade ore is hoisted and treated with the hand-picked ore coming from the mine. The minus 90-mm. material passes to another screen of 20-mm. mesh, the plus 20-mm. material going to a pickling belt, where ore, wood and waste are separated. The "armer Erzgröb," or low-grade coarse, drops into a bin. The minus 20-mm. material ("armer Erzgries," or low-grade fines) is partly screened through a 4-mm. sieve. The 4- to 20-mm. product and the 0- to 4-mm. product are called "armer Erzgries a and b," and are stored in ore

bins. The plus 2 per cent ore is crushed in a small crusher after the large pieces have been hand-cobbed to suitable size. The crushed product passes to a shaking screen equipped with a suction hood to avoid the dust problem. The material passing the screen is fed to crushing rolls, from where the ore passes to a revolving screen of 4-mm. mesh, which completes the classification. The over-size is returned to coarse crushing rolls with a bucket elevator and is screened into two products, which are fed to medium and fine crushing rolls. Both of these rolls feed a revolving screen of 4-mm. mesh, which again gives a coarse and fine product. This extensive crushing of the high-grade ore is believed to insure complete roasting in the furnaces and the consequent avoidance of large mercury losses. The richer the ores are, however, the less crushing is necessary, as the escape of the subliming cinnabar leaves a porous rock, the porosity being greater the richer the ore, so that there is no possibility of the rock entirely enclosing the cinnabar.

The dressing then gives the following product:

|                                        | Mercury<br>Per Cent | Mesh<br>Mm. |
|----------------------------------------|---------------------|-------------|
| a. Low-grade:                          |                     |             |
| 1. Low-grade coarse                    | 0.340               | 20 to 90    |
| 2. Low-grade fines                     | 0.463               | 0 to 20     |
| 3. Low-grade fines a                   | 0.440               | 4 to 20     |
| 1. Low-grade fines b                   | 0.815               | 4 minus     |
| b. Ores containing over 2 per cent Hg: |                     |             |
| 1. Fines                               |                     | 4 to 20     |
| 2. Dust                                |                     | 4 minus     |
| c. Ores containing over 5 per cent Hg: |                     | 4 minus     |

The ores, which are hauled to the plant by an electric locomotive, are carefully weighed and sampled. Ten grams is taken for an assay sample with low-grade ore, two grams for high-grade ore and 0.5 gram of the very rich material. Kroupa's modification of Eschka's gold cover assay method is used. The moisture is estimated at 2 per cent.

## OPERATION OF SHAFT FURNACES

The low-grade ores are burned in eleven shaft furnaces (Fig. 2), two of which have a circular cross-section and are slightly smaller than the others; the capacities are 15 tons in 24 hours for the larger and 13 tons for the two smaller ones. Some of these furnaces are equipped with Spirek's<sup>3</sup> automatic charging device, the others are closed with bell-like charge covers, through which the furnaces are charged every two and a half hours. The operation of the charging device is as follows: The iron hopper is filled with about 600 kg. ore from the charge car, and a load of charcoal ( $\frac{1}{2}$  cubic meter) or coal (60 kg.) is spread over it. The second charge car is held in reserve and

\*Translated from the *Oesterreichische Zeitschrift für Berg- und Hüttenwesen*, Vol. 62, 1914, by C. N. Schuette, Metallurgical Assistant, Bureau of Mines. The work was done in connection with a cooperative investigation of the metallurgy of mercury being carried on by the Bureau of Mines and the New Idria Quicksilver Mining Co., by whose courtesy reproduction is permitted.

<sup>1</sup>K. k. Bergdirektion zu Idria in Krain: Das k. k. Quecksilberwerk zu Idria. Zur Erinnerung an die Feier des 200 jährigen aush. sta. Besitzes, 1881; Karl Ritter: Über das alte und das moderne Quecksilberhüttenwesen in Idria, Vortrag auf den Bergmannstages in Klagenfurt, 1893; G. Kroupa: Notizen zur Quecksilberbestimmung nach A. Eschka, Jahrbuch der Bergakademien, 1889; Dr. A. Harpp: Der Idrianer-Schüttlofen und seine Verwendung zur Verhüttung von Quecksilberzen, Zeitschrift f. angew. Chemie, XVII. Jahrgang; Pilz: Überblick über den Quecksilberbergbau und Quecksilberhüttenbetrieb von Idria in Krain, Berg- u. Hüttenmännische Rundschau, IV. Jahrgang; T. J. Genter: the Quicksilver Mines of Idria, Eng. and Min. Journ., 1903; Franz Caské: Die Bestimmung und Verminderung der Verluste beim Quecksilberhüttenwesen, Jahrbuch der Bergakademien, 1910.

<sup>2</sup>Dr. R. Sterner-Rainer: Das Quecksilberwerk zu Idria in Krain. Paper presented May 9, 1911, in the *Freiburger Geologischen Gesellschaft*, V. Annual Report, 1912, p. 26.

<sup>3</sup>V. Spirek, Appareil de Chargement sans fumée Congrès International des mines, de la métallurgie, etc., 25, Juin jusqu'à 1. Juli, 1905, Section de métallurgie.

is dumped when the hopper begins to empty, which occurs when the water-sealed charge door cover is opened; the bottom of the hopper on which the charge rests now swings down on a frame which has moved across the charge opening. On closing, the charge hopper cover is replaced, the frame moves back, making room for the charge door cover; at the same time the hopper bottom is raised and the hopper can be refilled. This device works quickly and allows almost no escape of

This process is far too tedious to suit the workman. The gases above the cone were formerly drawn into a special condenser system, but the only result of this attempt was that the lowered pressure caused a greater flow of gas into the space between the cone and the charge-cover, and for this reason the device has been abandoned as impractical.

The tailings are drawn as fresh ore is charged, cooled with water and returned to the mine for fill. At the first removal of tailings during the morning shift, 10 kg. are taken as a sample, which are tested twice a month. The sample is reduced and about 10 or 20 grams are taken for assay. The tailings content varies between 0.0005 per cent and 0.0025 per cent. The crew is five chargemen and five drawmen. The shaft furnaces treat 42 per cent of the ore and their extraction equals 92.37 per cent of the contained mercury (loss 7.63 per cent).

#### OPERATION OF CERMAK FURNACES

The low-grade fines are treated in three old Cermak-Spirek fine-ore furnaces and one new and modified furnace of this type, which is fired with producer gas. The first Cermak fine-ore furnace erected in Idria was equipped with a "generator" at the ends of the furnace.

These generators, which, in construction as well as in operation, resembled "semi-gas producers," were not a success and were later replaced by grate fires, which system is still prevalent in the plant. Because of the importance of gas fuel to quicksilver metallurgy, a new solution of this problem was undertaken at the instigation of H. O. Kroupa, despite the former failure. The encouraging results will be discussed later on. Each of these older furnaces is really a combination of four 10-ton furnaces which have been joined in order to achieve a more efficient use of heat. Every 2½ hours, or three times per 8-hour shift, the tailings are drawn into an iron car. These are sampled with a long-handled scoop; the sample is reduced, mixed with

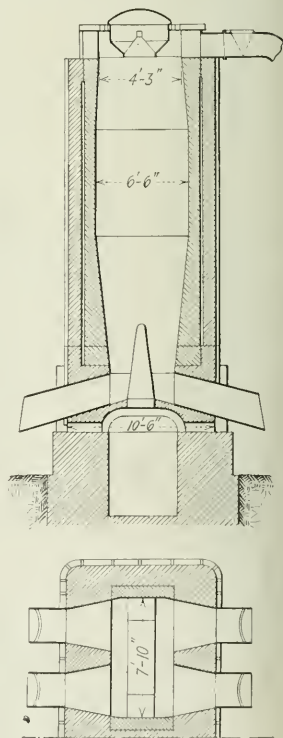


FIG. 2. VERTICAL SECTION OF NOVAK SHAFT FURNACE

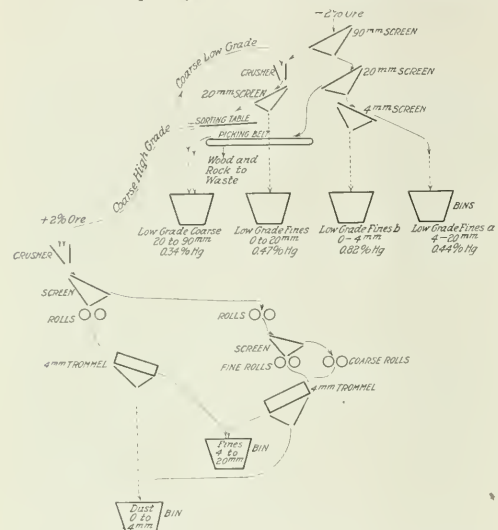


FIG. 1. CRUSHING AND SIZING PLANT AT IDRIA

charge gases and has proven very satisfactory, except that the trough of the water-lock can become clogged with ore or coal and so prevent complete sealing. The covers tend to warp with excessive temperatures and then close the opening imperfectly. A hole is left in the furnace top near the charge door, through which the height of the ore column can be measured with a wooden rod. This hole is stoppered with an oakum-bound iron plug. Generally, a single charge of two or three cars fills the furnace.

At the shaft furnaces, closed with a cone and cover device, the necessary number of charge cars is spotted, each second car being filled with the measured 2½ per cent of fuel. Here also wood and coal fuel are alternated from shift to shift in order to maintain a constant heat. Attempts to replace wood or coal by coke have not favored the latter practice. When the preparations are completed the counter-balanced cover is quickly raised by means of two levers; the cone is raised as soon as the ore has been dumped and the cover is quickly replaced. This operation is repeated until the furnace is filled. If the shaft becomes full, so that the ore no longer flows into it, the cone is replaced as well as it can be, and the circular hopper cover is set into its water seal. During this manipulation, which is quickly completed, some noxious gases escape from the furnace and the correct way of charging with this device would be not to lower the cone until the cover has been replaced and to repeat this process with each car of ore charged to the furnace.

hammerscale and heated for ten minutes (measured with an hour glass) over an alcohol flame. A completely burned charge should not give the faintest mirror of quicksilver on the enameled water-cooled cover of the



crucible. If no mirror is deposited, the tailings, which at most can contain 0.005 per cent Hg., are drawn into cars and hauled by a 10-hp. gasoline locomotive to a rock bin which is situated over a sluice leading to the Idriza River. After drawing, a corresponding amount of ore can be charged. The capacity of Nos. 1 to 3 furnaces, which are fired with beech or fir wood or with brown coal, is 45 tons of ore. Since one furnace block (that is, four shafts) has eight draw doors, eight cars at 0.5 tons each being drawn every  $2\frac{1}{2}$  hours, the same amount being charged, the ore remains in the furnace full 32 hours. The charged material is evenly spread about over the topmost furnace tiles with rakes. Since as in Italian practice the

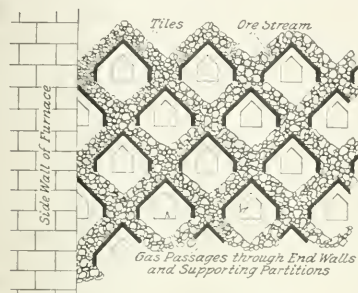


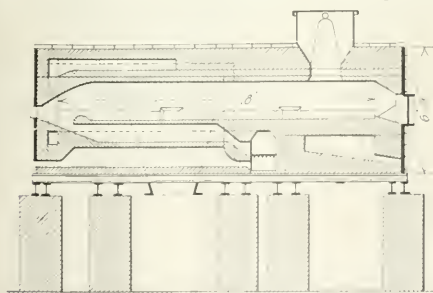
FIG. 3. CROSS SECTION SHOWING TILES IN CERMAK FURNACE

upper row of tiles is not connected with the furnace flue, and since the charge gases rising between the upper tile the roofs pass out through their own condenser system, the charge floor remains free of gas because the greater draft draws off the gases from beneath the upper gable. This also serves to remove the moisture which would otherwise condense on the charged ore. Even when the upper row of tiles becomes uncovered there is little evidence of escaping gas. As noted, these furnaces treat about 45 tons of low-grade fines per 24

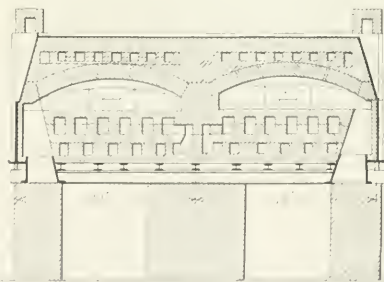
it is unnecessary to screen the low-grade fine ore, as it will even treat the dust successfully. The space between tiles (see Fig. 3) was fixed at 80 mm. instead of at 100 mm., as is customary in the old furnaces. Since gas fuel is used, the roasting zone in this furnace is increased, thus increasing the capacity. The furnace has ten rows of superposed gables with the same over-all height of the old six-gable fine-ore furnaces; for this reason the gables were made slightly flatter. Each of the four furnace shafts is divided into three parts by two walls, so that each gable, likewise divided into three tiles, can be more easily and cheaply be replaced if damaged. The two upper gables, which are made of cast iron, are kept under a greater draft than the other parts of the furnace. The two lower gables, which serve to preheat the air, are not heated except by descending hot ore. The flame may be regulated according to requirement and the feed of the producer gas may be regulated by suitably placed dampers.

The gas producer was originally designed for coal and wood, but was soon changed to an all-wood feed because of excess clinking. Supt. Slavik has successfully managed not only to dispose of the enormous development of wood tar by an improved condensation system, but has also devised a system by which one cord of wood can be charged into the generator at a time. The furnace results with producer-gas firing are satisfactory in every respect. The capacity of the furnace is now 85 tons per 24 hours, nearly 100 per cent greater than that of the grate-fired furnaces. The wood consumption per ton of ore treated (0.14 cubic meters) is no greater than before. Above all, the gas fuel not only causes a richer soot to form in the condensers (the soot being only slightly contaminated with tar and dust) but about half of this mercury is recovered as free metal. Less soot forms than formerly, which is beneficial not only from an economic but also from a hygienic viewpoint. For these reasons it is proposed to construct another of these furnaces of doubled capacity.

By the use of producer gas the temperature in any of the 12 gable rows can be raised to any desired de-



Longitudinal Section



Cross Section

FIG. 4. WOOD-FIRED REVERBERATORY FURNACES

hours, while broken tile in the furnace reduces the capacity to 40 tons. Such furnaces are charged with dustless fines, which it treats more advantageously and quickly.

In order to relieve the reverberatory furnaces treating minus 4-mm. ore, a gas-fired fine-ore furnace of 80-ton capacity was built a year ago. With this furnace

gree, as each of the gable rows can be heated individually. The flow of gas and air can be so regulated by means of dampers that a constant difference between the temperature of the roasting gases and the temperature of the ore can be maintained. According to Dennis<sup>1</sup> an even fall of potential of this kind increases

<sup>1</sup>Engineering and Mining Journal, 1909, No. 3.

the speed of the heat transfer in the furnace, so that a saving of time and fuel should result. Since the flow of air and gas can be completely controlled, the draft can be increased so that suction can be maintained even in the lowest row of gables, causing air to be drawn into the peepholes rather than letting gas escape from them. Not only can this regulation determine the speed of the gases through the condenser system, but the air around the furnace will be purer and healthier for the workmen.

The new furnace, which will be one meter higher than the others and have an automatic draw and the usual iron sheathing, will also be employed in furnacing

material have been developed. Last year 8 per cent of the tonnage was treated in these furnaces with a loss of 10.14 per cent of the input. Since low-grade dust, low-grade soot and pressed soot, however, will be treated in these furnaces for some time to come, they shall be briefly described. Fig. 4 shows these wood-fired reverberatory furnaces. The fuel consumption is 3 cubic meters of beech wood in 24 hours; this quantity is considerably less with very rich ore (over 50 per cent) as the combustion of the sulphur gives considerable heat independently of the heat from the fuel. The furnace will treat 7 tons of low-grade fines per 24 hours, but only half this tonnage of high-grade fines or soot:

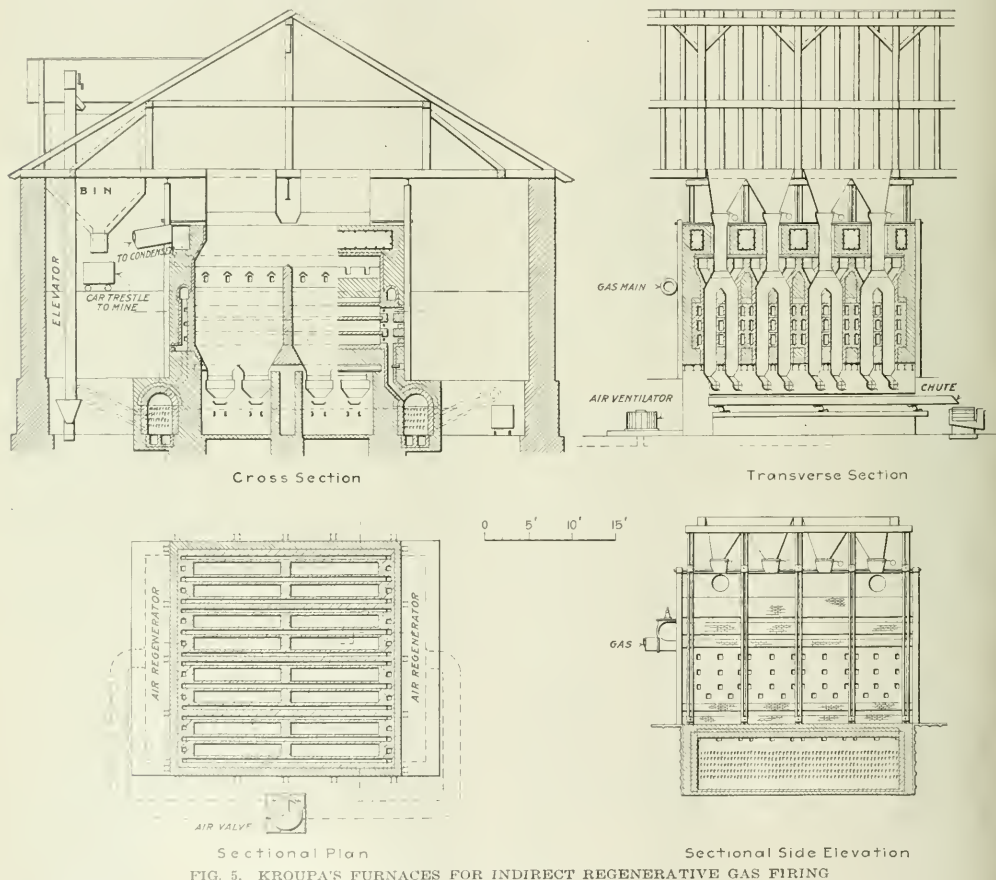


FIG. 5. KROUPA'S FURNACES FOR INDIRECT REGENERATIVE GAS FIRING

low-grade fine ore.<sup>6</sup> In the future, a system of conveyor belts will feed all furnaces.

The fine-ore furnaces, which treat about half the tonnage, give an extraction of about 88.39 per cent of the input, while the small fine-ore furnace, which treats the high-grade fines (6.63 per cent Hg), works with a loss of 8.34 per cent.

The six bottom-fired reverberatory furnaces are to be discarded, since better methods for treating the fine

thus 4.3 per cent of wood is needed for low-grade material and twice this amount with rich material. The charge is moved every half hour with a long iron rake, and after three hours (longer with rich material) it is moved to a space in front of the fire arch which has been cleared by the removal of the former charge. One charge car of low-grade or a half car of high-grade material is now charged through a cone and cover charging device. A quarter of an hour before drawing the tailings a sample is taken from the center of the hearth by inserting a suitable shovel which is introduced in-

<sup>6</sup>The furnace is already in operation. The results are as predicted, the capacity being 119 tons, and this may be increased later.—EDITOR.

verted and then turned over. This sample is tested as already described; if no mercury mirror is shown, the tailings are drawn into iron cars and transported hot to the dump, where an automatic device discharges them into a sluice. The burned soot is used over again to press fresh soot.

#### KROUPA'S SHAFT FURNACE

Encouraged by the favorable results achieved by producer gas fuel, the Idrian plant will make an attempt to treat the coarse ore by a method superior to that of burning in the shaft furnaces. In the coming year Kroupa's patented shaft furnace will be erected, which it is hoped will be a further step toward the perfecting of quicksilver metallurgy (Austrian Patent No. 62,517). The fundamental idea of this furnace construction is to sublime the cinnabar between highly heated walls, then burning it by allowing a sufficient amount of oxygen to enter, and finally condensing the free mercury. The column of coarse ore in the shaft is relatively narrow and allows a free passage of gas. The heat, which is derived from the combustion of producer gas, is utilized as efficiently as possible, and losses by radiation are avoided by reducing the radiating surface. This also lessens the diffusion of mercury vapor into the walls. The separation of the gases of combustion and the mercury fumes must result, first, in an almost complete condensation of the mercury, and, second, in a minimum formation of soot (or dust and bitumen). At the same time the saving of space will result in less labor being needed, and the greater tonnage handled will result in lower maintenance charges.

In the execution of these fundamental ideas the furnace was given the general shape of a cube having a length, width and height of about 9.3 meters, the regenerators being built along two sides (see Fig. 5). In this cube are eight vertical parallel shafts separated by walls built of refractory masonry and containing the heating flues. The shafts are 0.5 m. wide and 7.35 m. long and, including the charge shaft common to two roasting shafts, are 6 m. deep. The roasting zone formed by the heating flues has a height of 1.5 m. Each shaft is divided into two symmetrical parts by a transverse wall 370 mm. thick, located at its center. The ore is charged through a gas lock into the common shaft; on descending is divided into two streams by a gable-like edge and descends through the roasting zone in two columns, each 500 mm. thick.

The oxygen necessary for the combustion of the cinnabar vapor enters through an automatically controlled opening connected with the operation of the automatic draw machinery and is gradually heated to the temperature of the roasting zone. On leaving the roasting zone the gases preheat the descending ore in the charging shaft, so that the gases are fairly cool when entering the condenser.

The walls of the roasting shafts are heated by leading producer gas into the heating flues, where it mixes with the preheated air from the regenerator and burns. The discharged heating gases are led into the opposite regenerator, and when this is sufficiently heated the flow of both air and gas is reversed. This effects an even heating of both sides of the shaft and an even roasting of the charge. Judging from experiments at the Zink-

hütte Cilli and experience with gas-fired fine-ore furnaces, this furnace should have a greater capacity than that of the present shaft furnaces combined, and the method of treatment is very much simpler.

#### CONDENSATION OF MERCURY

The metal-bearing gases pass from the furnace to the condensers through cast-iron pipes. The Cermak condensers (Fig. 6), consisting of straight and curved stoneware pipes, or more recently of glazed tile, following a suggestion of H. Auhagen, have a short leg extending from the bottom of the U into a water-filled soot box. The inverted U is closed by a stoneware cover lying in an annular water-filled trough. A shaft or a reverberatory furnace has four lines of condensers, a fine-ore furnace eight or nine (the new one is to have fourteen). They are sprayed with water as evenly as

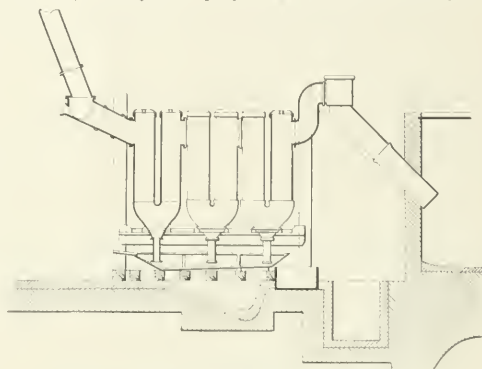


FIG. 6. THE CERMAK CONDENSERS

possible in order to cool the furnace gases. To keep the cooling water out of the soot boxes the condenser pipes stand in a large cup, only the short lower leg extending into the soot box. The extra condensers for drawing off the water vapor from the upper part of the fine-ore furnaces are similarly arranged. This line of condensers, fed by a separate exit pipe, consists of only two vertical pipes, which accounts for the greater draft. The exit pipes from the furnace must be made of iron, as they must resist a high temperature and great temperature variations. They are very resistant and may last twenty years. With even cooling and the avoidance of careless handling, stoneware (or still better, glazed tile) is the most resistant of materials. Cracks are filled with cement and the two parts are bound together with iron hoops, since leaks must be stopped immediately to avoid large mercury losses. The cooled gases leave the stoneware pipes, in which they deposit the greater amounts of mercury, soot, tar, ore dust and water, and pass into chambers (often common to several furnaces) divided into several parts by transverse walls. These transverse walls by forcing a change in direction of the gas stream effect a more complete settling of the dust.

The chambers and flues are made of tarred wood throughout, as this most easily resists the action of the gases. The individual boards forming the walls are held in place with wooden screws and are luted with tar. Since a considerable amount of rich soot gather-



in the first chamber, this is hopped into a soot box, so that the chamber can easily be cleaned. Each of the chambers can be cut out by means of dampers. A 16-hp. exhaustor having copper vanes and a capacity of 7 cubic meters of gas per second is built into the flue and gives a draft of 80 mm. of water.

It is also proposed to abandon the central subterranean condensation chamber, as it is not easy of access and the detection and repairing of leaks correspondingly difficult. The purpose of this chamber was to collect the damp, poor grades of soot called "arme Kammerstupp." The 14-m. stack which stands 146 m. above the general plant level will be removed and replaced with a 30-m. stack with a Wislicenius top. It still remains to be seen whether the Cottrell precipitator will be effective in condensing the residual bits of soot and mercury. The method is excellent for collecting dust, wet dust and liquid globules, though in the latter application it is difficult to insulate the electrodes. These difficulties might even be greater in collecting soot, but are probably not unsurmountable. Without doubt the improvements in quicksilver metallurgy must be sought for in the process of condensation, as the perfection of furnace construction has improved the roasting process enormously.

#### SOOT TREATMENT

The shaft furnaces which treat only low-grade but nearly dustless ores give a little very rich soot, which is cleaned up every two months. The soot derived from the low-grade fines and the low-grade fines a is cleaned up each month; the soot derived from the high-grade fines and from burning rich dust and pressed soot in

the soot boxes additional mercury can be drained off. No fuel is added and no ore is charged during the clean-up, to prevent mercury fumes from escaping and injuring the workmen. The condenser line to be cleaned is cut out of the furnace draft with dampers, the gases meanwhile passing through the other lines. The cement luting of the covers and cleanout holes of the pipes are cut away with sharp irons, the covers are removed and the soot swept into the boxes beneath with long-handled, double-faced brushes. The water in the soot boxes is siphoned off on the side away from the furnace and flows through gutters in the concrete floor to settling boxes and sumps, where any mercury in suspension may settle before the water flows to waste. The soot boxes are emptied, starting from the furnace side, the soot being dipped into buckets standing on a sheet-metal saucer to prevent spatter losses, long-handled dip-pers called "Gatzen" being used. As the soot becomes

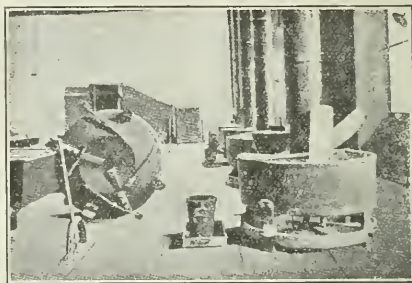


FIG. 8. NEW SOOT PRESS



FIG. 7. OLD SOOT PRESS

the reverberatory furnaces is cleaned up every fourteen days. The condensers of the reverberatory furnaces burning low-grade fines and furnace debris are cleaned up each month. Clean-ups are not needed oftener than every two weeks, even if 50 per cent ore is burned in these furnaces, as this does not form any additional soot and the mercury can be drawn from the traps into cast-iron pots without removing the soot. The collected mercury is dried with wood ashes and poured into storage flasks. This is also done before the clean-up at such other furnaces as yield a sufficient amount of free mercury. Since the mercury is mixed with the soot, it is necessary to agitate the latter in order to free the mercury. After the soot has been taken out of

very liquid after a part of it has been removed, burned pressed soot is added to thicken it, and finally the box is cleaned with these dry soot rejects.

Small amounts of metallic mercury are found in the soot boxes of even those furnaces treating very low-grade ore. If of considerable quantity it is poured into storage bottles; if not, it is dipped into the bucket with the soot. The filled buckets are taken to the soot mill in lots of six on a small iron flat car. A so-called "main clean-up" is held once annually, generally in July, during which the plant operation is entirely suspended, the furnaces repaired and the entire condenser system cleaned, including even the stack flue.

After the main clean-up the pipe soot and the rich chamber soot are put into boxes of about one cubic meter capacity, where they are allowed to settle. After a few days the clear water is siphoned off and the soot put into buckets and taken to the soot presses. Some metallic mercury always settles out on the bottoms of these boxes, and this mercury is poured into storage bottles holding about 60 kg. each; these are carried to the scales. An iron ring is placed in the box to facilitate the removal of metal; the soot in the ring is skimmed off, when the clean mercury, which enters between the ring and the bottom of the box, is dipped out.

One bucket of poor soot containing about 10 liters is generally sufficient for one soot-press charge (Figs. 7 and 8). With rich soot, which, however, is mainly metallic mercury, several buckets may be charged at once. When the press has been cleaned of the previous charge, a scoopful of lime is spread in it, the charge of

soot is added and covered with about three shovels of lime or burned soot rejects, and the machine is started. When the material has been well stirred additional lime is added until the mass becomes consistent; the time will depend on the moisture content and softness, but generally this stage is reached in half an hour. Most of the mercury is separated in about five minutes. To protect the workmen from mercury fumes, quicklime dust and the soot odor, the soot press is completely closed with a hinged cover containing a little charge hopper for the lime. The drain slots, on becoming clogged with soot, are cleaned by means of a mechanism which is actuated by a foot lever. Additional quicksilver flows out of the soot after each addition of lime, at first every two or three minutes, and later every four to six minutes. It gathers in the lowest part of the press and escapes through slots into a dish beneath, from which it runs to cast-iron pots, and is poured from time to time into storage bottles, which are taken to the weighing room. After pressing for about one hour (the pressing is really a mixing and continual cutting of the consistent mass), additional lime is added. The material then consolidates into lumps up to hazelnut size and yields no further mercury, which ends the pressing process. The soot press is now cleaned with a small, flat, chisel-like shovel, the walls and knives being scraped clean. The scrapings are removed with a scoop used to feed the lime. The pressed soot, consisting of dark to light gray nodules, is weighed and transported to the reverberatory furnaces to be furnace as rich ore, as it contains from 20 to 30 per cent mercury. Medium moist soot needs about thirty parts of lime to one hundred parts of soot. The soot presses are operated for one eight-hour shift per day. One press treats six or seven charges, although it could handle more; one operator per press is needed.

It has been tried to remove mercury from soot by centrifuging, but these experiments showed that in this process the soot consolidates into a hard mass without yielding its mercury. If, however, this treatment is preceded by a treatment with hot hydrochloric acid or by an extraction with carbon bisulphide, chloroform or ethyl acetate, the greater part of the metal will run together by centrifuging. The fundamental principle in the treatment with acid is the same as that employed in the soot presses. Instead of the saponification by means of the lime, which cleans the metallic particles of mercury from the adhering distillation and combustion products, we have in this treatment an acid saponification, while fats and oils are removed with the ether wash. This cleansing process allows the minute, disseminated particles of mercury to unite.

#### SHIPMENT AND PRODUCTION

Quicksilver is shipped in wrought-iron flasks holding 34.5 kg. Flasks destined for the Transvaal contain only 34 kg.; these flasks are designated with a red "T" and by being marked with red instead of white paint. The metallic mercury coming from condensers, soot boxes and soot presses is poured from oakum-stoppered storage bottles into an elevated iron pot. A drain pipe leads from the pot to a cylindrical clay weighing bucket with a conical bottom ending in an iron stop-cock, to which a hose is attached. When the beam balance points to zero the stop-cock is closed, the mercury is ac-

curately tared, and this mercury is run into the iron shipping flasks, which are then closed with a greased iron stopper. The flask is held in a vise while the stopper is screwed in. To test the shipping flasks for leaks they are inverted in an iron pan. If no leaks are found, it is ready for shipment. Some customers desire to receive their mercury in leather bags. For these it is filled in oiled sheepskin bags holding 25.08 kg. (55 lb.), two of these bags being shipped together in a small wooden keg.

The plant, which during the past year treated 117,110 tons of material, produced from these 762.5 metric tons (22,400 flasks) of metallic mercury.<sup>a</sup> Upon completion of the proposed improvements and plant additions, the production will probably increase considerably.

## Who and What Is the Employment Manager?

By C. T. CLAYTON

Director, Training and Dilution Service, United States Department of Labor

AS A MODERN business organization increases in complexity, further division of responsibility and more closely defined delegation of authority must be extended or the management will become chaotic. It is being recognized more and more that one most important function in a well-organized industrial establishment is the hitherto neglected responsibility of selection, placing and advancement of workers. This is what we mean by the term "employment management."

Employment management goes further, however, than merely concerning itself with such selection, placement and promotion. It investigates, as part of the selection, the character, experience and capacity of the applicant. It investigates for placement, and does not limit its investigation to the applicant. It sounds possibilities of openings for placement and it employs every means to secure the comfort and safety of the worker and thus assists his advancement by giving him a quiet mind and an assured future.

The employment manager is really the conscience of modern industry in practical action. In the old days, when employers had but few workers and themselves worked side by side with them, every worker was individually known to his boss, his idiosyncrasies were understood, his ambitions were appreciated because they were similar to the boss's ambitions. But now, when workers, numbered by the thousands, are employed by a collective boss who is a mere list of stockholders, living perhaps thousands of miles from the works and knowing the workers only as items of profit or loss on a ledger, some substitute for the old personal touch must be found or industry will become, first, congeries or unrelated items in reports, and, finally, mere anarchy. If modern industry is to be well-knit, is to understand and accomplish its real purposes, it must cultivate its conscience—the employment manager.

The usual method of business organization unfortunately has so far failed to take in this function as a distinct part of factory control. The foreman should not be charged with responsibility of selection of his gang. Good management does not require that he do so. Fac-

<sup>a</sup>Recovery, 6.5 kg. (14.3 lb.) per metric ton ore.

tory after factory has demonstrated that if the foreman's power includes that of sending back an unsatisfactory worker to the employment manager for removal and replacement, that is sufficient for purposes of discipline. But when it is considered that the cost of securing and training each worker ranges from \$10 to \$200, and averages probably more than \$60 each, a stupendous leak in the business which still clings to the antiquated foremanship hiring-and-firing methods is disclosed. Moreover, competent employment management reduces industrial misunderstanding and friction quite noticeably. In these days, when every nerve must be strained to obtain the highest possible output, no wise factory manager will ignore such a means of keeping the industrial peace.

Employment management differs from the public employment service. Some employers have been limiting their employment management to the status of mere labor recruiting agencies. That work should be left to the United States Employment Service; whose function is to find the labor and sift it in a preliminary way, offering those workers who seem likely to suit to the employment manager for his more intimate knowledge of the factory's needs, his more thorough methods of selection. The employment manager cannot be dispensed with in favor of the public employment agency any more than the public employment agency in this day of national need can be evaded. At least twelve millions of our working people are today engaged in the production and distribution of war supplies behind our military forces. Six millions or more will be required to fill the toll of increased demand brought about by the call of two millions to the colors before next July. Every available new source of labor must be tapped and carefully selected and trained before placing in industry.

### War Emergency Courses in Employment Management

An intensive training in employment management for men and women having a basic experience of at least three years' industrial experience and knowledge of factory methods has been arranged for in the following cities:

Boston—Harvard University, Massachusetts Institute of Technology, Boston University, New York—Bureau of Municipal Research. Rochester—University of Rochester. Pittsburgh—Carnegie Institute, University of Pittsburgh. Seattle, Wash.—University of Washington. Berkeley, Cal.—University of California. Courses are in preparation in Cincinnati at the University of Cincinnati, and in Chicago at the University of Chicago.

The courses, which run from six weeks to two months, are conducted by the Employment Management Division of the War Industries Board under the auspices of the Department of Labor, the War Department, the Navy Department, the United States Shipping Board and the Chamber of Commerce of the United States. There is no tuition fee. Employers having candidates for the courses and individual applicants desiring information should address Capt. Boyd Fisher, Employment Management Division, War Industries Board, 717 Thirteenth Street, N. W., Washington, D. C.

### New Jersey Chemical Society

At a meeting of chemists held at the Newark Technical School Monday evening, Oct. 28, action was taken in the matter of forming a permanent organization to promote the welfare of chemical industries and encourage the collegiate education of chemists in the State of New Jersey. The meeting was attended by more than fifty representative chemists of the state and assurance of cooperation and interest was given by forty-five others who were unable to attend. The title chosen for the organization was the New Jersey Chemical Society.

The first regular meeting for election of officers was held in the large auditorium of the Newark Technical School on Monday evening, Nov. 11. Applications for membership may be filed at future meetings. A constitution was adopted, and provision has been made for two classes of membership—firm members and individual members. It was the unanimous opinion of the meeting that this would insure for industrial chemists, for industrial corporations and for educational institutions in the state that close cooperation which will be so necessary in the development of the industries after the war.

The objects of the new organization as set forth are.

1. To provide opportunity for the periodic interchange of ideas relating to industrial chemistry.
2. To support, encourage and promote the general welfare of those industries of New Jersey which use chemicals and chemical processes.
3. To provide state commissions and municipal officials with competent guidance in problems of stream pollution, sewage disposal, water supply, fire prevention, pure food and health control, garbage disposal and street paving materials.
4. To provide a source for technical data relating to public utilities in order to promote the welfare of the State of New Jersey.
5. To further chemical education and provide standards of training for chemists in New Jersey.
6. To insure the permanency of chemical industries in the state by encouraging thorough collegiate training of chemists and providing a means of communication between chemical-industrial plants and our educational institutions.
7. To provide a means whereby banking institutions, investors, boards of trade and other commercial bodies may secure competent chemical advice.

The committee on organization consists of: Dr. Daniel R. Hodgdon, Newark Technical School; Dr. F. J. Pond Stevens Institute, Hoboken; Prof. Ralph G. Wright, Rutgers College, New Brunswick; H. B. Baldwin, chemist to the Board of Health, Newark; Carleton Ellis, consulting chemist, Montclair; Frederic Dannerth, consulting chemist, Newark; W. A. Lucas, the Butterworth-Judson Corporation, Newark; John Cawley, the Beckton Plant, du Pont Co. Newark; W. C. Stobaueus, the Charles Cooper Company, Newark; G. A. Prochazka, manufacturing chemist, Newark; James M. Reilly, the Board of Trade, Newark; Spencer Marsh, the National Newark & Essex Banking Co.; George T. Cottle, A. A. Wire Co., Inc., rubber covered wire; G. A. Armstrong, Central Dyestuff & Chemical Co.; W. E. Hadley, Clark Thread Mills, textile manufacturers; D. K. Howard, department of chemistry Newark Technical School; C. K. Simon, Dye Products & Chemical Co.; R. P. Calvert, du Pont de Nemours Co., Arlington; William A. Richey, National Carbon Co., Jersey City; S. Skowronski, Raritan Copper Works, Perth Amboy; C. L. Foster, Stubner Chemical Works, Elizabeth.



# Aluminium and Its Light Alloys—VI. Bibliography (a)

By PAUL D. MERICA

The following Bureau bibliography on aluminium and its light alloys is the supplement to the very comprehensive one assembled by the library of the United Engineering Societies and presented to the Bureau by Professor Zay Jeffries.

The numbers are references from the previous articles on the technology of aluminium in our issues of Aug. 1; light aluminium alloys, Aug. 15; miscellaneous alloys, Sept. 15; and Duralumin, Oct. 1.

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(To Be Continued)

## A Practical Oil Circulating System For Indirect Heating

THE rapid advance of the chemical and allied industries during the last decade has created a demand for equipment that was radical in design and which in many instances the market was unable to supply, as the new products and methods of manufacture required apparatus that up to that time had not been produced.

This condition was especially true in regard to the method of supplying heat to the new equipment. The chemists had performed their part, when they determined what ingredients should be used and how to prepare the final compound. It was now up to the engineer to furnish the means of producing it on a large scale.

Many products required high temperature in manufacture with perfect and instantaneous control and uniform heat distribution. Uniformity of treatment of the product was necessary. High pressures were not desirable because apparatus of complicated design and generally with its inner surfaces enamelled could not be economically built to withstand high pressures. Elimination of fire hazards was sought because the materials were organic and often of an inflammable nature. These severe demands had to be met with a heating system that must be thoroughly practical, clean, free from interruption and easily operated by unskilled attendants. Points of no less importance to be considered were low costs of apparatus, insurance rates, repairs and upkeep.

The only available methods of heating were by direct-fire, steam or electricity. Direct-fire could not meet these requirements because of the difficulties in con-

high pressures, heavy and expensive equipment, frequent packing blow-outs and repairs, sudden changes in temperature and its inefficient temperature gradient made superheated steam undesirable, even in the few cases where it could be used. The only other method commercially available was electric resistance heating, but this was not acceptable. The apparatus in most cases could not be readily adapted to this form of heating. First cost of apparatus was high, the fire hazard great and the operating cost exorbitant.

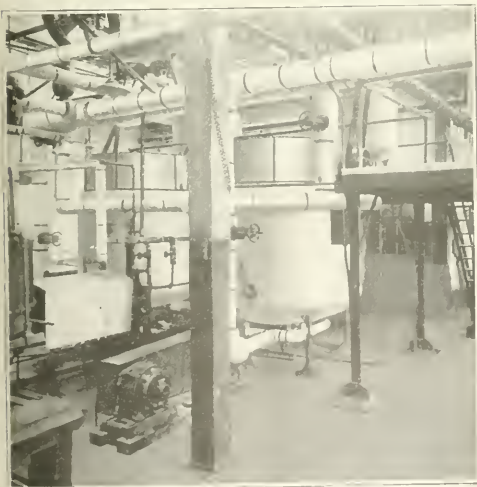
With these rigid specifications in view, engineers naturally turned their attention to something new and decided to try out a high temperature circulating liquid system of which the domestic hot water furnace is a prototype. The problem then resolved itself into finding a suitable liquid material for conveying the heat, one that could be safely heated up to high temperature without chemical change and be free from carbonization and, second, into designing a heater and apparatus for circulating the hot liquid between chemical apparatus and the heater.

A number of attempts were made to build oil circulating systems, but when they were put into operation they were not successful because the type of oil on the market was not suitable for this class of service inasmuch as it coked and clogged the system. It was soon learned that the heat could be designed only after careful study and semi-commercial experimenting. Other difficulties with pumps and leaky pipe lines soon made it appear as though this method could not be practically worked.

The engineers of the G. M. Parks Company of Fitchburg, Mass., anticipating a number of years ago the urgent and surely increasing demand for an oil circulating heating system that would meet the most exacting requirements of the manufacturer, have devoted their entire time to the solution of the many problems that arose in connection with the installation and operation of such a system. The system they have evolved comprises the following elements: The absorber or heater, the circulating equipment, special pipe fittings and the heat conducting oil. These elements are usually connected with any type of apparatus to which the heat to be furnished by them is to be delivered by circulation. The circulating oil is mechanically circulated and passes through a specially constructed heat absorber. Then it is pumped through pipes to the apparatus to be heated—jacketed kettles, stills, tanks, etc. After delivering a certain controlled portion of its heat, the circulating oil returns through the pump to the absorber for re-heating. The entire system is under hydrostatic pressure from an expansion tank open to the atmosphere. The only additional pressure, rarely exceeding 15 pounds, is due to the frictional resistance of the pumped liquid.

The absorber and fuel supply may be located at any reasonable distance from the manufacturing apparatus—completely isolated, if the product is inflammable. All fire risk thus can be avoided. The circulating oil is of the most importance and must have no free-carbon or inflammable distillate at 600 deg. F. Its copyrighted name is "meprolene."

Meprolene has very high flash and fire tests. It withstands high temperatures for indefinite periods. It



JACKETED MELTING KETTLES AND MEPROLENE LINES

trolling temperature, poor heat distribution and fire menace. Saturated steam did not provide high enough temperature ranges, so attention was turned toward superheated steam. The difficulties encountered with

does not carbonize, distill or "crack." It is made especially for use in this process.

The absorber is of peculiar design and consists of the heating element, which is built into a brick furnace. It has a dutch oven extension and is strongly reinforced by steel framework. The heating element is made of two-inch boiler tubes expanded into cast headers of heavy design. It is divided into one or more paths of flow to insure current consistent with maximum efficiency and heat transfer. Heavy plugs are screwed in the headers opposite the ends of each tube which permit of easy access to the inside of the tubes for cleaning. Cleanout doors in the furnace walls and insulated steel doors at each end of the absorber are easily removed and expose the entire heating element. Either fuel oil or gas can be used for heating.

The circulating equipment includes a Kinney positive displacement rotary pump, usually motor driven through silent gearings, the pump and motor being mounted on a unit sub-base.

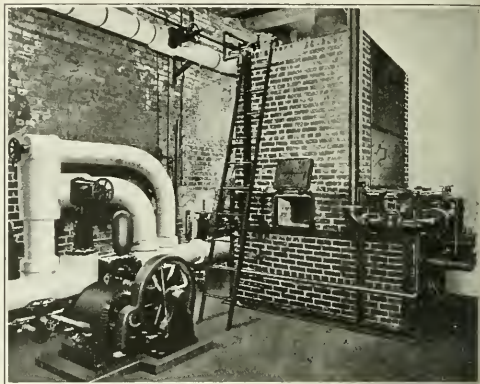
Pipe mains and all meprolene circulating lines are of standard weight steel pipe and, with the exception of the smaller sizes, have flanged connections. The flanges are made of forged steel and welded to the pipe. The gaskets used on the flanges are made for service in this class of work. Patented automatic valves give thorough protection from damage that might otherwise result from negligence or improper handling. These valves automatically shut off the fuel from the burners if there is any interruption to the flow of the meprolene or of compressed air when air atomizing oil burners are used. Other automatic devices can be attached to shut down the system if it is damaged by an external source.

Two accompanying photographs show a typical installation of the Merrill system of heat transmission, and two melting kettles which are part of a battery of six. At the particular plant where this system is installed, it was intended to use superheated steam for heating these kettles. The equipment was installed with all piping connections, valves, insulation, superheater, etc., but after several months had been spent in an endeavor to use superheated steam, this method was abandoned, as the superheating equipment could not furnish heat enough for even one kettle. The quantity of steam necessary was so great that it was decided to be entirely impracticable, if not impossible, to use it.

The photograph of the system shows a standard absorber with a normal heat output of 800,000 B.t.u. per hour, a circulating pump with a capacity of 160 g.p.m., a 10-hp. motor and all necessary accessories such as gages, thermometers, automatic valves, etc. This machinery is installed in a one-story building outside of the manufacturing plant. The floor space of this building is about 16 x 26 ft. City gas is used for fuel.

The battery of melting kettles is located on the third floor of the manufacturing building. They are approximately 5 ft. in diameter, 5½ ft. deep, open top, glass enamelled and equipped with agitators. The kettles have a jacket space of about three inches around the entire sides and bottom. Meprolene is circulated through four-inch pipe mains coming up from the absorber room. The meprolene enters the jackets at the bottom and exits from the top, returning to the absorber to be reheated. These kettles are used in the manufacture of a com-

pound the ingredients of which are charged into them at room temperature. These materials are fused and heated to 380 deg. F. The weight of a charge is three tons and the material has an average specific heat of 0.74, which includes the latent heat of fusion. After the compound has liquefied, 1700 pounds of water is added and this is raised from 60 to 212 deg. F. and completely evaporated in the process. This work is performed in about three and one-half hours time. The



KINNEY PUMP, ABSORBER AND CONTROL DEVICES

meprolene enters the jackets at 500 deg. F. and returns to the absorber at 475 deg. F. thus having a 25-deg. gradient.

In another manufacturing plant, batches of 3000 pounds of asphalt are being melted. The hot product is used in open pans for saturating purposes.

Three U-shaped jacketed kettles and ten long U-shaped jacketed saturating pans comprise the equipment.

As first installed, steam at 125 pounds pressure was the source of heat. High pressure in the jackets caused strains resulting in constant leaks, and soon the insulation was ruined. The absence of insulation made the room temperature unbearable in summer as well as increasing the fuel cost.

Steam at 125 pounds pressure has a corresponding temperature of 345 deg. F. The mixture required 300 deg. F. The thermic head was but 45 deg. F. With everything working as well as possible, the heat transfer was slow, but frequent delays caused by leaks, bothersome steam traps and reducing valves made production uncertain. The passing of the product to be coated through the saturating pans absorbed the heat so rapidly that frequent stops were necessary to permit the temperature to rise to a workable point again. Even with the highest attainable steam pressures uniformly good quality of product was not obtained.

The identical equipment now operates on a Merrill oil circulating system at 475 deg. F. The pressure is now but 14 pounds. Ample thermic head has assured steady production. Reduced pressure has stopped leaks. New insulation makes the work room more comfortable. The time of melting a batch is now thirteen hours as compared to thirty-two hours required with steam. The production decidedly increased, although there are 35 per cent fewer operatives employed.



Other installations have been made in a number of the leading plants throughout the country, and are used in the manufacture of chemicals, dyes, rubber wire insulation, roofing felt saturation, metal and paper coating and other industries were high constant temperatures and controllable heat are required.

These systems are built in a number of standard sizes, ranging in size from 50,000 to 1,300,000 B.t.u. per hour. Capacities greater than this are taken care of by connecting the absorbers in battery.

### Soldier Chemists Back to Industry

When the United States entered the European war one of the first problems to be considered was the effect of the draft upon essential industries. It was early appreciated that in order to maintain full efficiency it would be necessary to conserve as far as possible skilled workers and men with technical training. In order that we might not suffer from the depletion of our ranks, steps were taken to secure deferred classification and later on provision was made to furlough back to industry. This arrangement made it possible for chemical industries to maintain their efficiency and has contributed largely to the effectiveness of our forces in the field.

Up to the time of cessation of hostilities the Industrial Relations Branch of the Chemical Warfare Service had recommended for deferred classification 641 chemists and skilled workers. These recommendations were favorably considered, as a rule, by the Local Boards, and as a result about 90 per cent of the men so recommended were put in a deferred class. Many cases, however, were not brought to the attention of this branch until the men had actually been called into service. Such chemists or skilled workers as were essential to industry were then furloughed in order that the production of war materials might not be retarded. Through this method 156 men had been returned to industry, and at the time of the signing of the armistice 120 more cases were pending in the Adjutant General's Office.

As hostilities cease we naturally must again turn to peace-time conditions and look forward to the future development of chemical industry in America. The problem now before the Industrial Relations Branch of the Chemical Warfare Service is to assist chemists in service to secure positions where their training and experience can be used to the best interests of the Government. This enormous readjustment is rendered possible through the information gathered by Dr. Charles L. Parsons, secretary of the American Chemical Society, and through the questionnaires sent out by Major F. E. Breithut of the Personnel Division of the Chemical Warfare Service.

In order to accomplish results the chemists now in military service who desire to return to chemical industry are being requested to inform the chief of the Industrial Relations Branch concerning their future prospects, while the manufacturers are being asked to designate their requirements for chemists. The administration of this work will be carried out by the Industrial Relations Branch so that any information desired may be obtained by writing to Major Allen Rogers, Chief, Industrial Relations Branch, Chemical Warfare Service, 7th and B Streets, N. W., Washington, D. C.

### Société de Chimie Industrielle

Secretary Charles A. Doremus announces that a meeting of the New York Section of the Société de Chimie Industrielle will be held in Rumford Hall, 50 East 41st Street, on Tuesday evening, Nov. 19, beginning promptly at 8.30 o'clock.

The program for the evening will be: "Industrial Efforts in France During the War," Georges Maoussa, Docteur ès Sciences, member of the French High Commission; "The Electrochemical Industries in France," C. O. Mailloux, E.E., M.S., D.Sc., past president of the American Institute of Electrical Engineers; member of the American Industrial Committee to France; General Discussion of Ways and Means for Insuring the Further Development of the Société de Chimie Industrielle.

### \$100 Reward

A reward of \$100 is offered for the recovery of the platinum dishes and crucibles answering the following descriptions stolen from the Kentucky Agricultural Experiment Station, Lexington, Ky., during the week following Oct. 17, 1918, or for information leading to the conviction of the thief:

Platinum crucibles—No. 2, weighing 11.9750 grams, No. 3, 11.9703 grams, No. 10, 16.0273 grams, No. 13, 8.4319 grams, No. 18, 15.8232 grams, No. 22, 15.7905 grams, No. 26, 15.7580 grams, one not numbered, 18.9431 grams. Platinum dishes—No. 1, weighing 46.4689 grams, No. 11, 32.6709 grams, No. 12, 33.0927 grams, No. 14, 49.1097 grams, No. 15, 48.6788 grams, No. 20, 48.5347 grams, No. 22, 48.3856 grams, No. 23, 47.2223 grams.

## Personal

DR. ARTHUR L. DAY has presented his resignation as director of the Geophysical Laboratory, Carnegie Institution of Washington, effective Oct. 1, 1918, and will take up research on glass and allied materials for the Corning Glass Works in Corning, N. Y. Dr. Day has been director of the laboratory since its establishment in 1906, having been previously engaged in silicate researches at the U. S. Geological Survey in 1904 and 1905.

MR. F. N. FLYNN has resigned as general superintendent of the smelting and refining departments of the Consolidated Mining & Smelting Co. of Canada, Ltd., at Trail, B. C.

MR. L. H. GOEBEL is now associated with the engineering staff of Wallace & Tiernan Co., manufacturers of chlorine control apparatus and sanitary engineering specialties. He was formerly superintendent of filtration and chief chemist of the Water Filtration Plant of the Union Stock Yard & Transit Co., Chicago, Ill.

DR. ALCAN HIRSCH, chemical engineer of New York City, recently married Miss Edith D. Borg.

MR. DORSEY A. LYON of the U. S. Bureau of Mines has been placed in charge of the Pittsburgh Station as well as the other ten experimental stations of the Bureau. His headquarters will be in Pittsburgh.

MR. NATHAN OWITZ, for the past four years general manager of the J. P. Devine Co., Buffalo, N. Y., has resigned to accept the presidency and management of the Persol Chemical Corp., which he recently organized.

MR. CHARLES D. TEST, formerly chemist for the Western Potash Works of Antioch, Neb., has accepted a position on the staff of the United States Tariff Commission.

MR. B. H. TRIPP has been appointed district manager of sales for the Pacific Coast territory of the Chicago Pneumatic Tool Co. of Massachusetts. His office will be in San Francisco, Cal.

MR. WILLIS WERNER has been appointed chief chemist of the Republic Iron & Steel Co., Youngstown, Ohio. He will have charge of the blast furnace and open-hearth laboratories.

MR. F. W. BRUCKMILLER is now chemist for the Standard Oil Co. (Indiana), at Sugar Creek, Mo. He was formerly assistant professor of chemistry at the University of Kansas.

MR. ARTURO R. CALVO, for the past five years manager of sales of the Permutit Co., has resigned to become an officer and director of the Hercules Engineering Corporation and its affiliated interests, the Electrolytic Engineering Corporation and the Technical Products Co.

MR. FRANK D. CARNEY, chief metallurgist, and LEWIS B. LINDEMUTH, superintendent of the crucible and electric furnace departments of the Bethlehem Steel Co., Bethlehem, Pa., resigned their positions on Nov. 1 and have formed the partnership of Carney & Lindemuth, consulting engineers in iron and steel metallurgy and practical steel works operation, with offices at 40 Wall St., New York City.

MR. BENTON DALES is now research chemist for the B. F. Goodrich Co., Akron, Ohio, having formerly been head of the chemistry department of the University of Nebraska.

MR. ANDREW M. FAIRLIE, consulting chemical engineer, announces the opening of an office for general consulting practice at 1204 Third National Bank Building, Atlanta, Ga. Mr. Fairlie, who has been for several years chemical engineer for the Tennessee Copper Co., is still retained by that company in a consulting capacity.

PROFESSOR H. F. MOORE of the Engineering Experiment Station of the University of Illinois, Urbana, Ill., has been appointed, by the National Research Council, chairman of the committee to investigate the fatigue phenomena of metals.

MR. WILLIAM E. PULIS and MR. NATHAN M. CLARK have been elected vice-presidents of the Celluloid Co., 36 Washington Place, New York.

MR. RUSH T. SILL of the firm of Sill & Sill, consulting mining and metallurgical engineers, has received a commission as Captain of Engineers and is reporting at Fort Douglas.

MR. F. E. SMITH has accepted the position as chief engineer with the Barber-Greene Co., Aurora, Ill. Mr. Smith was formerly of the engineering department of the Stephens-Adamson Mfg. Co. and of the American Zinc & Chemical Co.

MR. R. H. WILSON has been appointed by the Walter A. Zelnicker Supply Co. as assistant to the president with an office at St. Louis. Mr. Wilson has been with the company for some time, latterly as Houston representative.

ing developed and introduced machinery and methods which are still in use in these industries. He was the inventor of the lead-zinc storage battery, and the first to commercially apply the storage battery to the propulsion of street cars. For many years he had resided in or near New York City, engaging in the profession of consulting chemist, and had also been widely employed as an expert in cases before the courts, involving complicated scientific and engineering questions. A veteran artilleryist of the Civil War, he had devoted his attention, since the entry of the United States into the present war, to the problem of accurate sighting of anti-submarine guns carried by aeroplanes and to chemical problems vital to the interests of our country in the war. He was a charter member of the American Society of Mechanical Engineers and of the American Electrochemical Society and a member of the American Chemical Society, the Society of Chemical Industry of Great Britain and various other scientific and literary bodies.

## Current Market Reports

### The Non-Ferrous Metal Market

**Thursday, Nov. 7.**—The non-ferrous metal market is likely not to alter immediately from its steady course at any single period during the prospective transition from a war basis to regular industrial pursuits. Antimony alone is declining, because the producers are forcing the market slightly to consume their offerings.

**Aluminum.**—The Government prices on ingots 98 to 99 per cent Al are \$660 a ton f.o.b. plant in 50-ton lots; \$662 down to 15-ton lots; and \$666 down to 1-ton lots, which prices will continue the remainder of the year. Prices per pound for small lots vary from 40c. to 45c.; sheet aluminum, 18 ga. and heavier, 42c.; powdered aluminum, 100 mesh, 70c.

**Antimony.**—Antimony continues to decline, not having a strong demand. Prices are between 9c. and 9½c. per pound.

**Chrome.**—Western production is now in slight excess of demand. The nominal quotation for 40 per cent ore is \$1.40 per unit, while 50 per cent ore is bringing \$1.70.

**Copper.**—The price of \$520 per ton for carload lots and 27.3c. per pound for small quantities was continued for another period at the conference held on Oct. 25 at Washington.

|                                 |     |        |          |
|---------------------------------|-----|--------|----------|
| Copper sheets, hot rolled.....  | lb. | \$0.36 | —\$0.37½ |
| Copper sheets, cold rolled..... | lb. | .37    | — .38½   |
| Copper bottoms.....             | lb. | .43    | — .45    |
| Copper rods.....                | lb. | .36    | — .37    |
| Copper wire.....                | lb. | .29    | — .30    |
| High brass wire.....            | lb. | .28    | — .29½   |
| High brass sheets.....          | lb. | .28    | — .29    |
| High brass rods.....            | lb. | .26    | — .28    |
| Low brass wire.....             | lb. | .32    | — .34    |
| Low brass sheets.....           | lb. | .32    | — .34½   |
| Low brass rods.....             | lb. | .32    | — .35    |
| Brazed brass tubing.....        | lb. | .37    | — .39    |
| Brazed bronze tubing.....       | lb. | .42    | — .44½   |
| Seamless copper tubing.....     | lb. | .41    | — .43    |
| Seamless bronze tubing.....     | lb. | .45    | — .46    |
| Seamless brass tubing.....      | lb. | .37½   | — .39½   |
| Bronze (gold) powder.....       | lb. | 1.00   | — 1.75   |

**Lead.**—The lead market is limited by selling restrictions, the supply being allocated by the Lead Committee. In carload lots at East St. Louis, the price is \$155 per ton. In New York all speculative and traders' lead has disappeared. The Lead Committee apportions lead at 8.05c. to legitimate consumers.

**Manganese.**—The scale prices on page 629 of CHEMICAL & METALLURGICAL ENGINEERING, June 15, prevail; the highest price per unit being \$1.35.

**Silver.**—Due to the flow of silver to Asia in payment for munitions and the greatly increasing industrial consumption in photography, motion picture reels and silverware, there is a shortage of silver even at the present Government price of \$1.01½ per ounce.

**Tin.**—The Tin Committee of the American Iron and Steel Institute has not yet announced the official price on tin. No doubt an understanding will have to be had with the producers before a final statement can be made public and as they are all in distant foreign countries, considerable

## Obituary

MR. WINTHROP R. CADY, sales manager of the Colorado Iron Works Co., died in Salt Lake City on Friday, Oct. 25, of pneumonia, following influenza at the age of 31. Mr. Cady had a record of seventeen years' continuous service with the Colorado Iron Works Co., and had a wide acquaintance among metallurgists and mining men of the West.

LIEUT.-COL. HARRISON, controller of the chemical warfare division of Great Britain, died of pneumonia Nov. 6. Lieut.-Col. Harrison took a leading part in the development of protective apparatus against gas attacks.

PROFESSOR WILLIAM MAIN, scientist and engineer, and formerly professor of chemistry in the University of South Carolina, died recently at his home in Piermont, N. Y., in his 74th year. He established the first assay office in the State of Colorado in 1866 and was one of the pioneers of the copper and lead mining industries of this country, hav-



time will elapse in intercommunication. During November 3575 tons entered our Pacific ports and 685 tons entered our Atlantic ports. The price is around 78c. lb., but there are no open transactions.

**Tungsten:**—The Western producers of scheelite are reluctant in offering at \$26 per unit. High grade wolframite is bringing \$25. Off-grade ores vary from \$20 to \$24.

**Zinc:**—Spelter is tending to decline slightly. East St. Louis is quoting \$173 per ton for spot, November delivery, \$174, December \$179, and January \$166. Zinc dust, 13¢ to 16c. per lb. Sheet zinc, 15c. per lb.

OTHER METALS

|                 |        |        |         |
|-----------------|--------|--------|---------|
| Bismuth .....   | lb.    | \$3.50 | —\$3.65 |
| Cadmium .....   | lb.    | 1.50   | —       |
| Cobalt .....    | lb.    | 2.50   | —3.50   |
| Magnesium ..... | lb.    | 1.75   | —2.10   |
| Mercury .....   | 75 lb. | 125.00 | —       |
| Nickel .....    | lb.    | 1.95   | —       |
| Nickel .....    | lb.    | .40    | — .43   |
| Tungsten .....  | lb.    | 34.00  | —       |
| Iridium .....   | oz.    | 175.00 | —       |
| Palladium ..... | oz.    | 135.00 | —       |
| Platinum .....  | oz.    | 105.00 | —       |

The Iron and Steel Market

The absorbing question before the iron and steel trade is the course of events in the market during the transitional period from war-time to peace-time conditions. For the longer future, the almost unanimous opinion is there will be heavy demand for iron and steel and at quite remunerative prices, but there must of necessity be a transitional period while the market finds itself or has the level found for it. Steel, in the final analysis, is used chiefly for construction purposes, money being invested in expectation of returns over a period of years. Some buyers of steel are justified simply in paying the current market price from week to week or month to month, but investment buying cannot proceed on that policy. There may be such a market decline in construction costs in three months as would equal the return on investment for several years, hence the investment buyer of steel must await settled conditions.

While the authorities at Washington have given to the press some intimations that cancellations of war contracts will be more or less gradual, it goes without saying that as to many items of war steel it would be a woeful waste of money to allow manufacture to continue a day longer than really necessary in the interest of maintaining conditions during the discussion and settlement of peace questions. There has been a tremendous production of shell steel and likewise a tremendous consumption of shells. When the consumption ceases the production should cease, because even at that the material in transit and in course of manufacture represents a very large stock of shells.

The authorities have made it clear to holders of large contracts that may be cancelled that the contractors will be treated fairly and that they will suffer no actual loss. The plan worked out, although not publicly announced, is that all material completed will be accepted and paid for, and all material in course will be purchased at a valuation including a pro rata of profit against the total profit that would accrue on the completed material. Material in course will be interpreted to include not only material in actual process of manufacture, but material definitely acquired for the purpose of filling the contract. Having purchased such material, the Government will sell it in the best market, in most cases doubtless to the contractor himself.

CONTROL IN TRANSITIONAL PERIOD

Several weeks ago it was plainly intimated that the War Industries Board desired to continue its regulation of industry after the termination of hostilities, for the purpose of protecting industry from violent reaction and establishing a permanent basis upon which industry could go ahead for the years of work that are to follow the war. Since then there has been active work on plans looking to the continuance of activity of various Government agencies for a period, perhaps six months, after the President's peace proclamation. The War Industries Board and the Food and Fuel Administrations would terminate upon the official declaration of peace. The Railroad Administra-

tion is legally empowered to continue for 21 months thereafter, while the Shipping Board continues indefinitely, and its present program, which it has announced lately is not to be altered, covers 15,000,000 tons deadweight of vessels, of which about 2,500,000 tons has thus far been built. A committee has been established to formulate a plan for the continuance of various control activities, and it is practically stated that such legislation as appears desirable will be sought from Congress. Apart from extension of the time limit of these activities, it is important that the relationship between the contemplated activities of the War Industries Board and the Sherman law should be established. As to iron and steel, the board has agreed with the producers upon certain maximum price limits, which could not be interpreted as in violation of the Sherman law, even if it had not been laid on the shelf or had something else done with it for the period of the emergency. The great majority of the trade, however, feels that what is to be needed for the next few months at least is the fixing of minimum prices, and if the board agrees with the producers on minimum prices, that constitutes an agreement also among the producers themselves, possibly quite another matter in the eyes of the Sherman law.

While there have been some clear evidences that some steel can be sold for export at prices above the Government limits, and it appears even that some such export orders have been booked, it is practically the unanimous opinion that if left to itself the domestic market in iron and steel would in no great while suffer a very severe slump while buyers were waiting for a stable market to be established. The familiar course, as exemplified over and over again in steel market history, is for prices to drop very sharply and to a level much below that which is subsequently established as a safe trading basis for all concerned. On the whole such disorganization is very undesirable, and it is undesirable to the Government, which expects to collect heavy taxes. There is a small minority in the trade that would probably welcome a slump, in expectation of its affording means for general reductions in cost of production, including reductions in wages. A couple of years ago such a view was indeed the common one, but meanwhile evidence has accumulated that a universal and heavy decline in wages and commodity prices cannot be expected, hence there has lately been very much less desire for a "shake-out" after the war than there was some time ago.

DIRECT GOVERNMENT INFLUENCE

That the Government will directly have great powers to exercise an influence upon steel prices is obvious, on account of the large purchases to be made for a long time to come by the Shipping Board and the Railroad Administration. It has lately become quite clear that the Government fully intends to exercise its power, that no purchases will be made that could afterward be called in question as representing an unwise use of public funds. For instance, the Railroad Administration has refused to approve the prices of \$55 and \$57 for bessemer and open-hearth rails agreed upon last September between the War Industries Board and the rail makers, and points out that the average price on rails bought by the roads long ago and still undelivered is about \$36. A dozen or more railroads protested against being required to accept freight cars allotted them from the 100,000 cars ordered by the Railroad Administration, asserting that the cars should be bought from the revolving fund and afterward sold to the railroads at something like peace-time prices. These protests have been overruled by the Railroad Administration, but subsequent purchases, which undoubtedly must be made, will naturally be at as low prices as can be compassed. Again, the Shipping Board has decided, although official announcement does not seem to have been made, to cut down the weekly plate allotment of 50,000 net tons for account of the Fleet Corporation to an amount not exceeding the actual flow of plates into hulls. A surplus of about a million tons has accumulated, representing a factor of safety when every possible ship counted, no matter what the expense, but too expensive to maintain for peace times. The 50,000



tons a week is equal to about 700,000 tons deadweight of vessels per month, while the actual rate of construction has averaged between 300,000 and 400,000 tons a month for several months past. The Director General of Shipbuilding has lately stated that 700,000 tons a month is the objective and that it is expected to be attained next spring. In the interim the plate quota will be reduced, by perhaps between 30 and 50 per cent, and the million-ton surplus may also be reduced, so that 50,000 tons a week of plates may not be called for again altogether as soon as vessel construction reaches 700,000 tons deadweight a month.

Thus the Railroad Administration and the Shipping Board will be able to exert a powerful influence toward a general reduction in steel prices, while on the other hand, when these Government instrumentalities purchase for peace times steel at certain prices, those prices will have considerable standing with the trade at large; and with the influence of the War Industries Board, together with such additional powers as may be granted it, there is opportunity promised for a safe and reasonable readjustment in iron and steel prices.

### The Chemical Market

**HEAVY CHEMICALS:**—The past two weeks have shown considerable lack of activity, with few transactions of note, other than the usual trading that is in evidence. Medicinal products were in strong demand and in most instances prices have had an upward tendency, while some of the other products that come under this heading were shaded in prices. One of these was caustic soda, which has developed a rather weak position, in view of the lack of buying interest, while its allied product, soda ash, has been more firm, although conditions relative to this material in the West and Middle West have not been so favorable.

**Bichromate of Soda:**—There has been continued inactivity in this market and the position of the item is apparently gaining no strength. In spite of the frequent cheap offerings that appear on the market there is a very noticeable lack of interest. At the close some sales were made at 19½c. for the standard brands, and most factors are now quoting at that figure.

**Soda Ash:**—A rather firm situation prevails in the East for this item where bag material is in strong demand, but barrels are more or less neglected, particularly so in the West and Middle West, where prices have been on the decline during the latter part of the past two weeks. Single bag material in New York was generally quoted at from \$2.65 to \$2.70, while in Chicago offerings were made at \$2.60. Double bags in the Middle West were held at \$3, while barrel material was offered at \$2.85, though in New York prices ranged from \$3.10 to \$3.15.

**Bleaching Powder:**—While stocks of this material are none too free for civilian consumption, the persistent demand that has been in evidence for a long period has eased up considerably during the latter part of the past two weeks. Some sales were consummated at 7c., though offerings at the close were heard as low as 6½c., with the general range of prices being 6½c. to 6½c.

**Caustic Soda:**—Considerable speculation is rife as to what the actual situation of this product may be, owing to the peculiar movement of late. However, most factors concede that its position is gradually weakening, particularly the solid material, while the ground seemingly maintains a more firm standing. Sales of the solid material are passing at some low levels, in some instances at \$4. Most factors now offer the 76 per cent solid at from \$4.15 to \$4.25, while the ground material is quoted at from \$5.15 to \$5.25.

**Bicarbonate of Soda:**—This market has developed a more steady tone and prices that have been soaring seemingly reached such an unusual mark that buyers were not disposed to meet. Consequently stocks have accumulated and prices declined from \$4.40 to \$4.25, which is still considered rather high.

**Quinine Sulphate:**—The Java brand, that has commanded considerable attention, also developed an easier position, but stocks are reported to be none too liberal in supply. Quotations generally heard range from \$1.04 to \$1.05.

**Citric Acid:**—Buyers have been showing very little interest at the close and prices therefore have declined from \$1.23 to \$1.15. Spot prices are now quoted at from \$1.15 to \$1.16 for the crystal material, and the powdered is offered at \$1.10.

**Yellow Prussiate of Potash:**—There has been a continued depreciation in price, with material liberally offered in many directions. Buyers have been showing very little interest in the material, in spite of the unusually cheap offerings, some being as low as 90c., while other quotations range from 95c. to \$1.

**COAL TAR PRODUCTS:**—During the interval no important price changes were noted for most of the intermediates, and where some were effected they were inclined upward. Trading in general has been rather quiet, but in view of this fact most of the products are in scarce supply. Para-aminophenol is one of the items which command considerable interest and may be safely classed as the feature of the products that come under this heading. Paraphenylenediamine is also in strong demand and stocks are reported to be in a somewhat depleted condition, while the position of paranitraniline is a trifle easier in stocks.

**Phenol:**—A rather firm situation prevails for this material, although the pronounced demand that has been in evidence for export purposes has slackened up considerably, particularly trading in the Far East. Local requirement is rather strong and trading is of sufficient volume to keep the market firm. Material with affidavit attached is held at 2c. more than for that of more recent manufacture.

**Benzol:**—Nothing of an important character has developed in this market. The item maintains a rather firm position and trading is of sufficient volume to take the slack off the market. Available material is fully in proportion to the current demand. Prices for the product in tank cars are subject to no change, though a slight increase is noted for drum material.

**Metatolulenediamine:**—Very little of the product is being offered; however, the consumption demand is not pressing, and in view of this fact the situation is being fairly well met. Prices are quotably unchanged.

**Para Amidophenol:**—There has been a continued depreciation in stocks and some important factors state they are in no position to offer, other than in occasional small quantities. Both the base material and H.C.L. are in firm demand, but quotations generally heard indicate no material change in prices.

**Benzidine:**—The only pronounced interest in this item is for the base material, which is being purchased quite freely for export purposes, while the local consumption is rather slow. The sulphate is more or less neglected with very little buying interest noted. Neither of the items has been affected by price changes.

**Saccharines:**—A peculiar situation continues to persist in this market, with the prospects small for any activity at the moment. A recent meeting held in New York City for the purpose of encouraging more interest in the item has apparently developed nothing particularly favorable up to the present writing. Prices have declined \$1 to \$2 and as much as \$3 in some instances for both the soluble and insoluble, which are now on a parity.

**H. Acid:**—Inquiry for this material continues to be very persistent and trading therefore is active. However, most factors in this line still report stocks very scarce, although more frequent offerings appear on the market. Prices are quotably unchanged and remain at firm levels.

**Aniline Oil:**—Due to the strong demand that has been prevailing for this material during the past few weeks, most directions state that stocks are in a depleted condition and very few spot offerings are now heard. A general advance in price of 1c. to 2c. has been made.

**Dinitrophenol:**—Offerings of this material for civilian consumption are no easier and the occasional lots which appear in the resale market originate considerable interest. But these are held at rather high prices, which apparently does not curtail trading.

## General Chemicals

WHOLESALE PRICES IN NEW YORK MARKET NOV 8, 1918

|                                                      |         |               |   |        |
|------------------------------------------------------|---------|---------------|---|--------|
| Acetic anhydride.....                                | lb.     | 1.60          | — | 1.85   |
| Acetone.....                                         | lb.     | .25           | — | .25    |
| Acetic, acetic, 28 per cent.....                     | cwt.    | 5.96          | — | 6.11   |
| Acetic, 36 per cent.....                             | cwt.    | 10.76         | — | 10.87  |
| Acetic, glacial, 99 1/2 per cent, carboys.....       | cwt.    | 19.00         | — | 19.20  |
| Boric, crystals.....                                 | lb.     | .13           | — | .15    |
| Citric, crystals.....                                | lb.     | 1.10          | — | 1.15   |
| Hydrochloric, C. P.....                              | lb.     | .08           | — | .08    |
| Hydrofluoric, 30 per cent, in barrels.....           | lb.     | .15           | — | .16    |
| Lactic, 44 per cent.....                             | lb.     | .05           | — | .07    |
| Lactic, 22 per cent.....                             | lb.     | .06           | — | .07    |
| Molybdic, C. P.....                                  | lb.     | 6.00          | — | 7.40   |
| Nitric, 36 deg.....                                  | lb.     | .08           | — | .10    |
| Nitric, 42 deg.....                                  | lb.     | .04           | — | .04    |
| Oxalic, crystals.....                                | lb.     | .40           | — | .43    |
| Phosphoric, 47-50 per cent paste.....                | lb.     | .07           | — | .10    |
| Phosphoric, ref. 50 per cent.....                    | lb.     | .35           | — | .40    |
| Picric.....                                          | lb.     | .75           | — | .85    |
| Pyrogallol, resublimed.....                          | lb.     | 3.25          | — | 3.50   |
| Sulphuric, 60 deg.....                               | ton     | 16.00         | — | 16.00  |
| Sulphuric, 66 deg.....                               | ton     | 25.00         | — | 25.00  |
| Sulphuric, oleum (Fuming), tank cars.....            | ton     | 60.00         | — | 65.00  |
| Tannic, U. S. P., bulk.....                          | lb.     | 1.40          | — | 1.50   |
| Tartaric, crystals.....                              | lb.     | .86           | — | .95    |
| Tungstic, per lb. of W.....                          | lb.     | 1.70          | — | 1.75   |
| Alcohol, sugar cane, 188 proof.....                  | gal.    | 4.91          | — | 5.00   |
| Alcohol, wood, 95 per cent.....                      | gal.    | .91           | — | .92    |
| Alcohol, denatured, 180 proof.....                   | gal.    | .68           | — | .69    |
| Alum, ammonia lump.....                              | lb.     | .06           | — | .06    |
| Alum, chrome ammonium.....                           | lb.     | .18           | — | .19    |
| Alum, chrome potassium.....                          | lb.     | .22           | — | .22    |
| Alum, chrome potassium.....                          | lb.     | .12           | — | .13    |
| Alum, potash lump.....                               | lb.     | .09           | — | .10    |
| Aluminium sulphate, technical.....                   | lb.     | .02           | — | .02    |
| Aluminium sulphate, iron free.....                   | lb.     | .03           | — | .04    |
| Ammonia, 28 deg., carboys.....                       | lb.     | .08           | — | .09    |
| Ammonia, anhydrous.....                              | lb.     | .08           | — | .08    |
| Ammonium carbonate.....                              | lb.     | .12           | — | .13    |
| Ammonium nitrate.....                                | lb.     | .12           | — | .15    |
| Ammonium, sulphate domestic.....                     | lb.     | .07           | — | .08    |
| Amyl acetate.....                                    | gal.    | 5.30          | — | 5.35   |
| Arsenic, white.....                                  | lb.     | .09           | — | .13    |
| Barium carbonate, 99 per cent.....                   | ton     | 80.00         | — | 90.00  |
| Barium carbonate, 97-98 per cent.....                | ton     | 65.00         | — | 67.00  |
| Barium chloride.....                                 | ton     | 70.00         | — | 80.00  |
| Barium sulphate (Blanc Fixe, Dry).....               | lb.     | .04           | — | .05    |
| Barium nitrate.....                                  | lb.     | .12           | — | .14    |
| Barium peroxide, basis 70 per cent.....              | lb.     | .30           | — | .32    |
| Bleaching powder, 35 per cent chlorine.....          | lb.     | .06           | — | .07    |
| Borax, crystals, sacks.....                          | ton     | .08           | — | .08    |
| Bromine, crude.....                                  | ton     | 65.00         | — | 70.00  |
| Bromine, technical.....                              | lb.     | .75           | — | .75    |
| Calcium acetate, crude.....                          | lb.     | .04           | — | .05    |
| Calcium, carbide.....                                | lb.     | .16           | — | .17    |
| Calcium chloride, 70-75 per cent, fused, lump.....   | ton     | 22.00         | — | 24.00  |
| Calcium peroxide.....                                | lb.     | .50           | — | 1.70   |
| Calcium phosphate.....                               | lb.     | .12           | — | .23    |
| Calcium sulphate, 98-99 per cent.....                | lb.     | .09           | — | .09    |
| Carbon bisulphide.....                               | lb.     | .08           | — | .09    |
| Carbon tetrachloride, drums.....                     | lb.     | .60           | — | .70    |
| Carbonyl chloride (Phosgene).....                    | lb.     | 1.10          | — | 1.50   |
| Caustic potash, 88-92 per cent.....                  | lb.     | .67           | — | .72    |
| Caustic soda, 76 per cent.....                       | 100 lb. | 4.40          | — | 4.45   |
| Chlorine, liquid (Government Purchase).....          | ton     | (Fixed Price) | — | .07    |
| Coal oil.....                                        | lb.     | 1.60          | — | 1.65   |
| Copperas.....                                        | lb.     | .02           | — | .02    |
| Copper carbonate.....                                | lb.     | .30           | — | .31    |
| Copper cyanide.....                                  | lb.     | .75           | — | .78    |
| Copper sulphate, 99 per cent, large crystals.....    | lb.     | .09           | — | .09    |
| Cream of tartar, crystals.....                       | lb.     | .75           | — | .85    |
| Epsom salt, bags, U.S.P.....                         | 100 lb. | 3.62          | — | 3.90   |
| Formaldehyde, 40 per cent.....                       | lb.     | .02           | — | .03    |
| Glauber's salt.....                                  | lb.     | .63           | — | .65    |
| Glycerine, bulk, C. P.....                           | lb.     | 4.25          | — | 4.30   |
| Iodine, resublimed.....                              | lb.     | .13           | — | .15    |
| Iron oxide.....                                      | lb.     | .17           | — | .17    |
| Lead acetate, white crystals.....                    | lb.     | .15           | — | .18    |
| Lead arsenate (Paste).....                           | lb.     | .12           | — | .12    |
| Lead nitrate.....                                    | lb.     | .12           | — | .14    |
| Lith. are, American.....                             | lb.     | 1.50          | — | 2.05   |
| Lithium carbonate.....                               | lb.     | .16           | — | .17    |
| Magnesium carbonate, technical.....                  | lb.     | .14           | — | .15    |
| Nickel salt, single.....                             | lb.     | .12           | — | .13    |
| Nickel salt, double.....                             | lb.     | 1.10          | — | 1.50   |
| Phosgene (see Carbonyl chloride).....                | lb.     | 1.00          | — | 1.15   |
| Phosphorus, red.....                                 | lb.     | 1.10          | — | 1.20   |
| Phosphorus, yellow.....                              | lb.     | .45           | — | .46    |
| Potassium bicarbonate.....                           | lb.     | .125          | — | 1.26   |
| Potassium carbonate anhydrous.....                   | lb.     | .38           | — | .40    |
| Potassium chlorate, crystals.....                    | lb.     | .38           | — | .40    |
| Potassium cyanide, 98-99 per cent.....               | lb.     | .35           | — | .38    |
| Potassium iodide.....                                | ton     | 300.00        | — | 350.00 |
| Potassium muriate, 80-85 p. c. basis of 80 p. c..... | ton     | .15           | — | .20    |
| Potassium nitrate.....                               | lb.     | 1.85          | — | 2.00   |
| Potassium permanganate, U. S. P.....                 | lb.     | 2.30          | — | 2.50   |
| Potassium prussiate, red.....                        | ton     | .95           | — | 1.05   |
| Potassium prussiate, yellow.....                     | lb.     | .42           | — | .48    |
| Potassium sulphate, 90-95 p. c. basis 90 p. c.....   | lb.     | .22           | — | .24    |
| Potassium sulphate, 90-95 p. c. basis 90 p. c.....   | 100 lb. | 1.40          | — | 1.65   |
| Potassium sulphate, 90-95 p. c. basis 90 p. c.....   | ton     | 18.00         | — | 20.00  |
| Potassium sulphate, 90-95 p. c. basis 90 p. c.....   | oz.     | .63           | — | .64    |
| Potassium sulphate, 90-95 p. c. basis 90 p. c.....   | 100 lb. | 2.65          | — | 3.80   |
| Potassium sulphate, 90-95 p. c. basis 90 p. c.....   | 100 lb. | 3.25          | — | 3.80   |
| Sodium acetate.....                                  | lb.     | .04           | — | .04    |
| Sodium bicarbonate, domestic.....                    | lb.     | .21           | — | .22    |
| Sodium bicarbonate, English.....                     | lb.     | .21           | — | .22    |
| Sodium bicarbonate.....                              | lb.     | .21           | — | .22    |
| Sodium bisulphite, powder.....                       | lb.     | .25           | — | .25    |
| Sodium chloride.....                                 | lb.     | .10           | — | .10    |
| Sodium cyanide.....                                  | lb.     | .37           | — | .38    |
| Sodium fluoride, commercial.....                     | lb.     | .10           | — | .18    |

|                                             |         |      |   |      |
|---------------------------------------------|---------|------|---|------|
| Sodium hyposulphite.....                    | lb.     | 2.80 | — | 3.00 |
| Sodium molybdate, per lb. of Mo.....        | lb.     | 2.50 | — | 3.00 |
| Sodium nitrate, 95 per cent.....            | 100 lb. | 4.12 | — | 5.00 |
| Sodium nitrite.....                         | lb.     | .27  | — | .30  |
| Sodium peroxide.....                        | lb.     | .35  | — | .45  |
| Sodium phosphite.....                       | lb.     | .35  | — | .40  |
| Sodium prussiate, yellow.....               | lb.     | .39  | — | .40  |
| Sodium silicate, liquid (60 deg.).....      | lb.     | .04  | — | .05  |
| Sodium sulphide, 30 per cent, crystals..... | lb.     | .07  | — | .08  |
| Sodium sulphide, 60 per cent, fused.....    | 100 lb. | .11  | — | .11  |
| Sodium sulphite.....                        | lb.     | .05  | — | .06  |
| Strontium nitrate.....                      | lb.     | .25  | — | .30  |
| Sulphur, chloride, drums.....               | lb.     | .07  | — | .08  |
| Sulphur dioxide, liquid, in cylinders.....  | lb.     | 1.50 | — | .40  |
| Sulphur, flowers, sublimed.....             | 100 lb. | 4.35 | — | 4.50 |
| Sulphur, roll.....                          | 100 lb. | 3.20 | — | 3.85 |
| Sulphur, sublimed.....                      | lb.     | .65  | — | .70  |
| Tin bichloride, 50 deg.....                 | lb.     | .38  | — | .29  |
| Tin oxide.....                              | lb.     | .18  | — | .20  |
| Zinc carbonate.....                         | lb.     | .15  | — | .15  |
| Zinc chloride.....                          | lb.     | .15  | — | .15  |
| Zinc cyanide.....                           | lb.     | .13  | — | .14  |
| Zinc dust, 350 mesh.....                    | lb.     | .02  | — | .04  |
| Zinc sulphate, American process XX.....     | lb.     | .04  | — | .06  |

## Coal Tar Products (Crude)

|                                             |      |               |   |       |
|---------------------------------------------|------|---------------|---|-------|
| Benzol, pure, water white.....              | gal. | .22           | — | .27   |
| Benzol, 90 per cent.....                    | gal. | .25           | — | .30   |
| Toluol, in tank cars.....                   | gal. | (Fixed Price) | — | 1.50  |
| Toluol, for non-military use, in drums..... | gal. | (Fixed Price) | — | 1.55  |
| Xylo, pure, water white.....                | gal. | .45           | — | .55   |
| Solvent naphtha, water white.....           | gal. | .18           | — | .25   |
| Solvent naphtha, crude, heavy.....          | gal. | .45           | — | .55   |
| Creosote oil, 25 per cent.....              | gal. | .45           | — | .55   |
| Dip oil, 20 per cent.....                   | gal. | .30           | — | .32   |
| Pitch, various grades.....                  | ton  | 8.00          | — | 20.00 |
| Carbolic acid, crude, 95-97 per cent.....   | lb.  | 1.05          | — | 1.10  |
| Carbolic acid, crude, 50 per cent.....      | lb.  | .60           | — | .65   |
| Carbolic acid, crude, 25 per cent.....      | lb.  | .35           | — | .38   |
| Creosol, U. S. P.....                       | lb.  | .19           | — | .20   |

## Intermediates, Etc.

|                                       |     |       |   |       |
|---------------------------------------|-----|-------|---|-------|
| Alpha naphthol, crude.....            | lb. | 1.00  | — | 1.10  |
| Alpha naphthol, refined.....          | lb. | 1.50  | — | 1.60  |
| Alpha naphthylamine.....              | lb. | .55   | — | .60   |
| Aniline oil, drums extra.....         | lb. | .30   | — | .32   |
| Aniline salts.....                    | lb. | .45   | — | .45   |
| Anthracene, 80 per cent.....          | lb. | .08   | — | .08   |
| Benzaldehyde (f.f.c.).....            | lb. | 4.25  | — | 4.50  |
| Benzidine, base.....                  | lb. | 7.00  | — | 8.00  |
| Benzidine, sulphate.....              | lb. | 1.40  | — | 1.45  |
| Benzoic acid, U. S. P.....            | lb. | 3.00  | — | 3.10  |
| Benzoyl chloride.....                 | lb. | 2.90  | — | 3.00  |
| Benzoyl chloride.....                 | lb. | 2.45  | — | 2.50  |
| Beta naphthol benzate.....            | lb. | 10.00 | — | 12.00 |
| Beta naphthol, sublimed.....          | lb. | .75   | — | .85   |
| Beta naphthylamine, sublimed.....     | lb. | 2.65  | — | 3.00  |
| Dichloro-benzol.....                  | lb. | 4.00  | — | 4.50  |
| Diethylaniline.....                   | lb. | .36   | — | .38   |
| Dinitro-benzol.....                   | lb. | .40   | — | .45   |
| Dinitrochlorobenzol.....              | lb. | .60   | — | .60   |
| Dinitrophenol.....                    | lb. | .65   | — | .65   |
| Dinitrotoluol.....                    | lb. | .55   | — | .60   |
| Dinitrophenol.....                    | lb. | .65   | — | .65   |
| Dimethylamine.....                    | lb. | 1.00  | — | 1.10  |
| Diphenylamine.....                    | lb. | 3.25  | — | 3.50  |
| H-acid.....                           | lb. | 1.85  | — | 2.05  |
| Metaphenylenediamine.....             | lb. | .09   | — | .10   |
| Monochlorobenzol.....                 | lb. | .11   | — | .12   |
| Naphthalene, flake.....               | lb. | 1.20  | — | 1.30  |
| Naphthalene, balls.....               | lb. | 1.00  | — | 1.10  |
| Naphthalene, acid, crude.....         | lb. | .45   | — | .50   |
| Naphthylamine, 98-sulphonie acid..... | lb. | .55   | — | .60   |
| Nitro naphthalene.....                | lb. | 6.50  | — | 7.00  |
| Ortho-amidophenol.....                | lb. | 1.00  | — | 1.10  |
| Ortho-dichloro-benzol.....            | lb. | .75   | — | .85   |
| Ortho-toluidine.....                  | lb. | 4.25  | — | 5.00  |
| Ortho-nitro-toluidine.....            | lb. | 15.00 | — | 20.00 |
| Para-amidophenol, base.....           | lb. | 1.85  | — | 2.05  |
| Para-amidophenol, II, C. L.....       | lb. | .15   | — | .20   |
| Para-dichloro-benzol.....             | lb. | 1.80  | — | 1.95  |
| Paranitraniline.....                  | lb. | 1.50  | — | 1.60  |
| Paranitro-toluidine.....              | lb. | 4.00  | — | 4.50  |
| Paraphenylenediamine.....             | lb. | 2.25  | — | 2.50  |
| Para toluidine.....                   | lb. | 4.25  | — | 5.00  |
| Phthalic acid anhydride.....          | lb. | 4.25  | — | 5.00  |
| Phenol, U. S. P.....                  | lb. | 4.00  | — | 5.00  |
| Resorcin, technical.....              | lb. | 7.50  | — | 8.00  |
| Resorcin, pure.....                   | lb. | 1.50  | — | 2.00  |
| Salicylic acid.....                   | lb. | .31   | — | .33   |
| Sulphanilic acid, crude.....          | lb. | 2.50  | — | 3.00  |
| Toluidine.....                        | lb. | .85   | — | .90   |
| Toluidine-mixture.....                | lb. | .85   | — | .90   |

## Petroleum Oils

Crude (at the Wells)

|                             |      |      |   |      |
|-----------------------------|------|------|---|------|
| Pennsylvania.....           | bbl. | 4.00 | — | 4.00 |
| Cornish, Ohio.....          | bbl. | 2.85 | — | 2.85 |
| Somerset, Ky.....           | bbl. | 2.60 | — | 2.60 |
| Wessex, Ohio.....           | bbl. | 2.68 | — | 2.68 |
| Indiana.....                | bbl. | 2.28 | — | 2.28 |
| Illinois.....               | bbl. | 2.22 | — | 2.22 |
| Oklahoma and Kansas.....    | bbl. | 2.22 | — | 2.22 |
| Caddo, La., light.....      | bbl. | 2.25 | — | 2.25 |
| Corsicana, Tex., light..... | bbl. | 2.25 | — | 2.25 |
| California.....             | bbl. | 1.35 | — | 1.57 |
| Gulf Coast.....             | bbl. | 1.90 | — | 1.90 |
| Mexican.....                | bbl. | 1.90 | — | 1.90 |
| Fuel Oil                    |      |      |   |      |
| New York.....               | gal. | .15  | — | .15  |
| Philadelphia.....           | gal. | .07  | — | .15  |
| Baltimore.....              | gal. | .07  | — | .10  |
| Pittsburgh.....             | gal. | 1.04 | — | 1.04 |
| Texas.....                  | bbl. | 1.85 | — | 2.35 |
| Los Angeles.....            | bbl. | 1.65 | — | 1.65 |

| Gasoline (Wholesale) |      |        |        |
|----------------------|------|--------|--------|
| New York, motor      | gal. | 24 1/2 | —      |
| Gas machine          | gal. | 24 1/2 | —      |
| 72-76 degrees        | gal. | 33 1/2 | 39 1/2 |
| 70-72 degrees        | gal. | 32 1/2 | 37 1/2 |
| 67-70 degrees        | gal. | 30 1/2 | 36 1/2 |
| Pittsburgh, motor    | gal. | 25 1/2 | 26 1/2 |
| Chicago, motor       | gal. | 22 1/2 | 23 1/2 |
| Oklahoma, motor      | gal. | 21 1/2 | 22 1/2 |
| San Francisco, motor | gal. | 20 1/2 | 21 1/2 |

### Paraffine Waxes

|                              |     |        |        |
|------------------------------|-----|--------|--------|
| Crude, 103 to 105 deg. m.pt. | lb. | 08 1/2 | —      |
| Crude, 118 to 120 deg. m.pt. | lb. | 09 1/2 | —      |
| Crude, 124 to 126 deg. m.pt. | lb. | 10     | —      |
| Refined, 120 deg. m.pt.      | lb. | 13 1/2 | —      |
| Refined, 128 deg. m.pt.      | lb. | 14 1/2 | —      |
| Refined, 135 deg. m.pt.      | lb. | 16     | 16 1/2 |
| Ozokerite, brown             | lb. | 75     | 80     |
| Ozokerite, green             | lb. | 85     | 90     |

### Lubricants

|                                              |      |    |    |
|----------------------------------------------|------|----|----|
| Black, reduced, 29 gravity, 25-30 cold test. | gal. | 24 | 25 |
| Cylinder, light                              | gal. | 39 | 50 |
| Cylinder, dark                               | gal. | 39 | 43 |
| Paraffine, high viscosity                    | gal. | 40 | 41 |
| Paraffine, 0.903 sp. gr.                     | gal. | 36 | 38 |
| Paraffine, 0.885 sp. gr.                     | gal. | 26 | 28 |

### Flotation Oils

(Prices at New York unless otherwise stated)

|                                                                   |      |    |    |
|-------------------------------------------------------------------|------|----|----|
| Pine oil, crude, f. o. b. Florida                                 | gal. | 44 | —  |
| Pine oil, steam-distilled, sp. gr. 0.925-0.940                    | gal. | 58 | 60 |
| Pine oil, destructively distilled                                 | gal. | 58 | 60 |
| Pine-tar oil, sp. gr. 1.02-1.035                                  | gal. | 35 | —  |
| Pine-tar oil, double refined, sp. gr. 0.965-0.990                 | gal. | 42 | —  |
| Pine-tar oil, ref., light, sp. gr. 0.950, tank cars, f.o.b. works | gal. | 37 | —  |
| Pine-tar oil, ref., heavy, sp. gr. 1.025, tank cars, f.o.b. works | gal. | 28 | —  |
| Pine-tar oil, ref., thin, sp. gr. 1.060-1.080                     | gal. | 32 | —  |
| Turpentine, crude, sp. gr. 0.870-0.900                            | gal. | 45 | —  |
| Hardwood oil, f.o.b. Michigan, sp. gr. 0.960-0.990                | gal. | 23 | —  |
| Hardwood oil, f.o.b. Michigan, sp. gr. 1.06-1.08                  | gal. | 23 | —  |
| Wood creosote, ref., f.o.b. Florida                               | gal. | 31 | —  |

### Naval Stores

|                                          |          |       |       |
|------------------------------------------|----------|-------|-------|
| Rosin A-E barrel                         | 280 lb.  | 15.35 | 15.65 |
| Rosin F-I                                | 280 lb.  | 15.65 | 16.00 |
| Rosin K-O                                | 280 lb.  | 16.00 | 17.00 |
| Rosin W-X                                | 280 lb.  | 17.00 | 17.50 |
| Spirits of turpentine                    | gal.     | 73    | —     |
| Wood turpentine, steam distilled         | gal.     | 62    | 65    |
| Wood turpentine, destructively distilled | gal.     | 58    | —     |
| Fitch                                    | 200 bbl. | 8.00  | —     |
| Tar, kiln dried                          | 280 lb.  | 13.00 | 13.50 |
| Retort tar                               | 280 lb.  | 14.00 | 14.50 |
| Rosin oil, first run                     | gal.     | 80    | —     |
| Second run                               | gal.     | 83    | —     |
| Third run                                | gal.     | 88    | —     |
| Fourth run                               | gal.     | 98    | —     |

### Vegetable Oils

|                          |      |        |        |
|--------------------------|------|--------|--------|
| Castor oil               | lb.  | 34     | 38     |
| China wood oil           | lb.  | 27     | 28     |
| Cocoonut oil             | lb.  | 16 1/2 | 22     |
| Corn oil                 | lb.  | 18     | —      |
| Cottonseed oil, crude    | lb.  | 20     | 22     |
| Lined oil, raw, cars     | gal. | 1.81   | 1.86   |
| Olive oil                | gal. | 4.25   | 4.50   |
| Peanut oil, crude        | lb.  | 18     | 22     |
| Soya bean oil, Manchuria | lb.  | 17     | 18 1/2 |

### Glues

|                            |      |      |      |
|----------------------------|------|------|------|
| Extra white                | lb.  | 36   | 45   |
| Cabinet                    | lb.  | 31   | 40   |
| Brown foot stock           | lb.  | 18   | 22   |
| Fish glue, 50-gal. barrels | gal. | 1.00 | 1.80 |

### Miscellaneous Materials

|                                     |         |         |        |
|-------------------------------------|---------|---------|--------|
| Barytes, floated, white, foreign    | ton     | Nominal | —      |
| Barytes, floated, white, domestic   | ton     | 33.00   | 36.00  |
| Beeswax, white, pure                | lb.     | 63      | 65     |
| Beeswax, unbleached                 | lb.     | 43      | 48     |
| Blanc fixe                          | lb.     | 05 1/2  | —      |
| Casolin                             | lb.     | 17 1/2  | 30     |
| China graphite                      | lb.     | 25      | 25     |
| Chalk, light, precipitated, English | lb.     | 04 1/2  | 06     |
| China clay, imported, lump          | ton     | 20.00   | 40.00  |
| China clay, domestic, lump          | ton     | 15.00   | 22.50  |
| Fluorspar                           | ton     | 8.00    | 12.00  |
| Fluorspar, gravel, f.o.b. mines     | ton     | 28.00   | 40.00  |
| Fluorspar, washed, powdered         | ton     | 90.00   | —      |
| Fuller's earth, powdered            | 100 lb. | 1.50    | 2.00   |
| Japan wax                           | lb.     | 26      | 19     |
| Mexican graphite                    | ton     | 60.00   | 75.00  |
| Madagascar graphite                 | lb.     | 10      | 15     |
| Orange shellac                      | lb.     | 72      | 80     |
| Pumice stone                        | gal.    | 08      | 04     |
| Red lead, dry, carloads             | 100 lb. | 11 1/2  | 11 1/2 |
| Sapstone                            | ton     | 15.00   | 25.00  |
| Stearic acid, 120 deg. m.pt.        | ton     | 13      | 14     |
| Stearic acid, 140 deg. m.pt.        | ton     | 18      | 19     |
| Talc, American, white               | ton     | 20.00   | 40.00  |
| White lead, dry                     | ton     | 09 1/2  | 10 1/2 |

### Refractories, Etc.

(F.O.B. Works)

|                                   |          |        |        |
|-----------------------------------|----------|--------|--------|
| Chrome brick                      | net ton  | 175.00 | —      |
| Chrome cement                     | net ton  | 75.00  | —      |
| Clay brick, first quality freelay | per 1000 | 50.00  | 55.00  |
| Clay brick, second quality        | per 1000 | 35.00  | 40.00  |
| Magnesite, raw                    | ton      | 30.00  | 35.00  |
| Magnesite, calcined, powdered     | ton      | 50.00  | 65.00  |
| Magnesite, dead burned            | net ton  | 50.00  | 60.00  |
| Magnesia brick, 9x4x2 1/2         | net ton  | 110.00 | 125.00 |
| Silica brick                      | per 1000 | 50.00  | 60.00  |

### Ferroalloys

|                                                                    |     |        |        |
|--------------------------------------------------------------------|-----|--------|--------|
| Ferrocobalt, 15-18 per cent, carloads, f.o.b. Niagara Falls, N. Y. | ton | 200.00 | 250.00 |
| Ferrocobalt                                                        | lb. | 15     | 30.00  |
| Ferrochromium, per lb. of Cr.                                      | lb. | 30     | 40     |
| Ferromanganese, domestic, 70 per cent basis                        | ton | 250.00 | —      |
| Ferromanganese, English                                            | ton | 325.00 | —      |
| Spiegel, 16-18%                                                    | ton | 75.00  | —      |
| Ferromolybdenum, per lb. of Mo.                                    | lb. | 3.50   | 4.50   |
| Ferroalicon, 75 per cent, f.o.b. N. Y.                             | ton | 153.00 | 160.00 |
| Ferrosilicon, 50 per cent, contract                                | ton | 2.35   | 2.40   |
| Ferrotungsten, 75-85 per cent, f.o.b. Pittsburgh                   | lb. | 7.50   | —      |
| Ferroumranium, f.o.b. works, per lb. of U.                         | lb. | —      | —      |
| Ferrovandium, f.o.b. works                                         | lb. | —      | —      |

### Ores and Semi-finished Products

|                                                       |      |       |        |
|-------------------------------------------------------|------|-------|--------|
| Chrome ore, 45 per cent minimum, f.o.b. Cal. per unit | ton  | 1.50  | 1.55   |
| Chrome ore, 45 per cent and over, New York, per unit  | ton  | 1.40  | —      |
| Coke                                                  | ton  | 6.00  | 7.00   |
| Manganese ore, 48 per cent and over, per unit         | ton  | 31.00 | —      |
| Manganese ore, chemical                               | ton  | 80.00 | 100.00 |
| Molybdenite, per lb. of MoS <sub>2</sub>              | lb.  | 1.25  | 1.50   |
| Tungsten, Scheelite, per unit of WO <sub>3</sub>      | ton  | 24.00 | —      |
| Tungsten, Wolframite, per unit of WO <sub>3</sub>     | ton  | 25.00 | —      |
| Uranium oxide, 96%                                    | lb.  | 3.25  | 3.60   |
| Vanadium pentoxide, 99%                               | lb.  | 10.50 | —      |
| Pyrites, foreign                                      | unit | 17    | —      |
| Pyrites, domestic                                     | unit | 28    | 30 1/2 |

### Plant Supplies

#### BUILDING MATERIALS

|                                         |         |        |        |
|-----------------------------------------|---------|--------|--------|
| Common clay bricks                      | M       | 13.00  | 14.00  |
| Hollow tile, 4 x 12 x 12                | M       | 60.00  | —      |
| Hollow tile, 12 x 12 x 12               | M       | 170.00 | —      |
| Lime                                    | ton     | 16.50  | —      |
| Portland cement                         | bbl.    | 2.59   | —      |
| Single glass (82-lb.), 10 x 26-16 x 24  | ton     | 21.00  | 27.00  |
| Double glass (164-lb.), 10 x 26-16 x 29 | ton     | 31.00  | 39.00  |
| Yellow pine lumber                      | M       | 39.00  | 45.00  |
| Fir lumber                              | M       | 38.00  | 53.00  |
| Hemlock                                 | M       | 24.50  | 40.00  |
| Tarred lath (14-lb.)                    | ton     | 68.00  | —      |
| Roofing pitch                           | ton     | 27.00  | —      |
| Asphalt coated roofing (35-55-lb.sq.)   | sq.     | 1.60   | 2.45   |
| Slate surfaced asphalt shingles         | sq.     | 5.25   | 5.50   |
| Corrugated galvanized iron              | ton     | 109.00 | 127.00 |
| Fatty                                   | 100 lb. | 6.25   | —      |
| Red oxide (Fp'te. Coppers)              | 100 lb. | 15.00  | 20.00  |
| Native red oxide                        | 100 lb. | 3.25   | 8.00   |
| Red metallic paint                      | 100 lb. | 1.20   | 1.50   |
| White lead in oil                       | 100 lb. | 11.84  | 14.00  |
| Red lead in oil                         | 100 lb. | 12.28  | 14.50  |
| Zinc oxide (dry)                        | 100 lb. | 13.00  | 14.50  |
| Zinc oxide—leaded                       | 100 lb. | 9.00   | 10.00  |
| Yellow ochre                            | 100 lb. | 1.50   | 10.00  |
| Ultra marine blue                       | 100 lb. | 14.00  | 50.00  |
| Prussian blue                           | 100 lb. | 135.00 | 150.00 |
| Chrome green                            | 100 lb. | 40.00  | 70.00  |
| Paris green                             | 100 lb. | 40.00  | 65.00  |
| Mineral black                           | 100 lb. | 1.75   | 2.25   |
| Powdered bone black                     | 100 lb. | 5.50   | 12.00  |
| Lampblack                               | 100 lb. | 15.00  | 45.00  |
| Gas carbon                              | 100 lb. | 16.00  | 25.00  |
| Mexican petroleum pitch                 | 100 lb. | 1.00   | 2.00   |
| Gilsonite                               | 100 lb. | 2.00   | 2.50   |
| Coal tar pitch                          | 100 lb. | 60     | 1.25   |

#### STRUCTURAL IRON

|                                   |     |        |        |
|-----------------------------------|-----|--------|--------|
| Blue annealed sheet iron          | ton | 84.00  | 89.00  |
| Black sheet iron                  | ton | 96.00  | 104.00 |
| Galvanized iron                   | ton | 105.00 | 135.00 |
| Tern plate, 8-lb. coating         | ton | 150.00 | —      |
| Tern plate, 15-lb. coating        | ton | 177.50 | —      |
| Tern plate, 25-lb. coating        | ton | 202.50 | —      |
| Tern plate, 40-lb. coating        | ton | 240.00 | —      |
| Tip plate, prime                  | ton | 155.00 | —      |
| Tank plates                       | ton | 65.00  | 70.00  |
| Beams, channels, angles, T's, Z's | ton | 60.00  | 65.00  |
| Rivets                            | ton | 88.00  | 92.00  |
| Steel pipe, 2 to 3-inch           | ton | 51.00  | —      |
| Bar iron and steel                | ton | 60.00  | 70.00  |
| Chain (1 inch proof coil)         | ton | 150.00 | —      |
| Nails, bolts, nut washers         | ton | 70.00  | 80.00  |
| Tool steels, special alloys       | ton | 300.00 | 500.00 |
| Bessemer pig iron                 | ton | 36.60  | —      |
| Bessemer steel                    | ton | 45.50  | —      |
| No. 2 foundry                     | ton | 32.90  | —      |
| Steel billets (4 x 4)             | ton | 47.50  | —      |

#### POWER HOUSE SUPPLIES

|                              |     |         |     |
|------------------------------|-----|---------|-----|
| Steam packing, rubber duck   | lb. | 99      | 110 |
| Asbestos, high pressure      | lb. | 1.76    | —   |
| Asbestos, wire               | lb. | 1.50    | —   |
| Asbestos, graphited braid    | lb. | 1.21    | —   |
| Asbestos, wick               | lb. | .75     | —   |
| Rubber, sheet                | lb. | .66     | —   |
| Cup grease                   | lb. | .07     | —   |
| Transmission grease          | lb. | .07     | —   |
| Axle grease                  | lb. | .04 1/2 | —   |
| Grease, cup                  | lb. | .04 1/2 | —   |
| Cotton waste                 | lb. | 75      | 13  |
| Hose, underwriters, 2 1/2 in | ft. | 75      | —   |
| Hose, air, 2 in              | ft. | 30      | 60  |



# INDUSTRIAL

Financial, Construction and Manufacturers' News

## Construction and Operation

### Alabama

**CHOCTAW POINT**—The Consumers Dry Woods Products Co., Mobile, will increase the capacity of its plant.

### Arizona

**FLAGSTAFF**—The Navajo Copper Co. will build a leaching plant having a daily capacity of 100 tons. G. A. McCollough, manager.

**KINGMAN**—The Industrial Finance Co., 50 East 42nd St., New York City, N. Y., will build a 40 x 140 ft. plant for the production of fiber and fiber products from the Yucca plant.

**PATAGONIA**—The Mowry Mining Co. will build a new concentration plant at its local mining properties.

**TUCSON**—The Pima County Smelting Co. will build a large reduction plant to provide for increased operations. Address C. M. Garrison.

### Arkansas

**BATESVILLE**—Dr. Tooker will build a manganese washing plant here and is in the market for a log washer, belts, power, jig irons, pulleys and shafting.

### California

**COVINA**—The city has awarded the contract for the installation of a chlorination plant at the intake of the city reservoir supplying water for domestic use, to the California Jewell Filter Co. Estimated cost, \$8,000.

**MARE ISLAND**—The Bureau of Yards and Docks, Navy Department, Washington, D. C., plans to build an oxy-acetylene generating plant, under Specification No. 3522, noted Oct. 15.

**MARTINEZ**—The Shell Oil Co. will build an addition to its refinery. Estimated cost, \$80,000.

**MELROSE** (Oakland P. O.)—The National Lead Co. will build several reinforced-concrete factory buildings here. Estimated cost, \$300,000. H. A. Broberg, 485 California St., San Francisco, is preparing plans, \$25,391.

**SAN DIEGO**—L. M. Cox, Commandant, 12th Naval District, has awarded the contract for the construction of seven air school buildings, on North Island, to the Los Angeles Planning Mill Co., 1812 Industrial St., Los Angeles. Project includes the construction of laboratories, oil storage and reclaiming buildings, etc. Total estimated cost, \$50,000.

**SAN FRANCISCO**—The Bureau of Foreign and Domestic Commerce, 307 Custom House, has information regarding a firm in Russia which is in the market for complete equipment for a sulphate-cellulose mill and a paper factory. Refer to file No. 20200.

### Colorado

**LEADVILLE**—The Fanny Rawlings Mining Co. will rebuild its surface plant recently destroyed by fire, entailing a loss of \$13,000. W. C. Frost, superintendent.

### Connecticut

**PLAINVILLE**—The Trumbull Electric Manufacturing Co., Woodward Ave., has awarded the contract for the construction of a sewage disposal plant to A. D. Marco, Southington. Estimated cost, \$10,000. Noted Nov. 15.

### Delaware

**WILMINGTON**—The E. I. du Pont de Nemours Co. will build a two-story plant 45 x 50 ft. addition to its local organic laboratory. Estimated cost, \$25,000.

### Kansas

**TREECE**—Col. & Matthews, Picher, Okla., will remove its plant from Picher to

Treece and remodel same. The company is in the market for roofing, cement, mill hardware, pipe, pump, sludge tanks, bolts, concrete and lumber. Estimated cost, \$40,000. J. H. Kleinfelter, superintendent.

### Maryland

**BALTIMORE**—The United States Emergency Fleet Corporation, Housing Department, 253 Broad St., Philadelphia, Penn., will build a sewage disposal plant here. Estimated cost, \$50,000. Norton, Bird & Whitman, Munsey Building, engineers.

### Massachusetts

**HINGHAM**—The Bureau of Yards and Docks, Navy Department, Washington, D. C., will build a TNT plant here. Estimated cost, \$150,000.

### Michigan

**DETROIT**—The Construction Division of the War Department, Washington, D. C., has awarded the contract for the construction of a factory building; acid plant here. Estimated cost, \$150,000.

**DETROIT**—The Cummings & Moore Graphite Co., 672 Water St., has awarded the following contracts for the construction of a factory building; carpentry, to David J. Osgood, 220 West Elizabeth St.; masonry, to Stokes & Whittingham, Penobscot Building. Noted Oct. 31.

### Minnesota

**WORTHINGTON**—The State Board of Control will build a filter plant having a capacity of 80,000 gal. and a pumping plant; filter equipment will be installed in same. D. F. Mullen, secretary. L. P. Wolfe, 1000 Guardian Life Building, St. Paul, engineers.

### Missouri

**JOPLIN**—The Badger Mining Co. has awarded the contract for the construction of a concentration plant, to Edgar Foster. Estimated cost, \$56,000.

**JOPLIN**—The Freehold Oil & Gas Co. has taken over two leaseholds in the Waco-Lawton field, and will build a 200-ton mill on each tract. W. S. Marquiss, Weh Chy, manager.

**KANSAS CITY**—The Jensen-Salsberry Laboratories, 1320 Main St., will build a three-story, 56 x 120 ft. rein.-forced concrete and brick laboratory. Estimated cost, \$65,000. E. O. Brostrom, 212 Leeward Building, architect. Noted June 20.

### New Jersey

**CAPE MAY**—The Bureau of Yards and Docks, Navy Dept., Washington, D. C., will receive bids until Nov. 15 for the construction of a blacksmith, coppersmith and electric shop. Specification No. 3051. Estimated cost, \$20,000.

**CLAREMONT**—The Standard Oil Co., 26 Broadway, New York City, will build a reinforced-concrete filter and tank house at its Eagle works here.

**NEW JERSEY CITY**—The Davis-Bournonville Co., Van Wagon Ave., manufacturer of acetylene goods, will build an addition to its plant. Estimated cost, \$75,000.

**NEW JERSEY CITY**—The Van Dyke Chemical Co., 57 Wilkison Ave., will rebuild its plant recently destroyed by fire entailing a loss of \$10,000.

**NEWARK**—The Butterworth-Judson Corporation, Avenue R, will install a large quantity of new nitrating equipment to replace the chemical stoneware now in use.

**NEWARK**—The Oxwell Acetylene Co., 410 Frelinghuysen Ave., has awarded the contract for the construction of a three-story, 42 x 100 ft. factory addition to Fred K. Reus, 1320 6th St. Estimated cost, \$19,500. Noted Oct. 31.

### New York

**BROOKLYN**—McGosson & Robins, 91 Fulton St., New York City, will build a two-story, 60 x 80 ft. factory addition for the manufacture of drugs on North 11th and Perry St. Estimated cost, \$35,000. T. Engelhardt, 305 Broadway, architect.

**BROOKLYN**—The Ohio City Oil Co., Varick Ave., has awarded the contract for the construction of alterations to its plant, to the William Kennedy Construction Co., Montague St. Estimated cost, \$10,000.

**BROOKLYN**—The Standard Oil Co., 26 Broadway, New York City, has awarded the contract for the construction of an addition to its plant at the Gowanus Canal and 2nd St., to the H. W. Smith Contracting Co., 385 Lexington Ave., New York City. Estimated cost, \$25,000.

**BUFFALO**—The Aluminum Castings Co., 2800 Harvard Ave., Cleveland, Ohio, has awarded the contract for the construction of a three-story laboratory at 1850 Elmwood Ave., to the Schaaf Construction Co., Buffalo. Estimated cost, \$20,000. Noted Nov. 15.

**BUFFALO**—The Donner Steel Co., 375 Abbott Road, will build a concrete and steel laboratory and engineering office. Estimated cost, \$35,000.

**BUFFALO**—The Prest-O-Lite Co., 266 Amsterdam Ave., New York City, has awarded the contract for the construction of a plant which consists of 4 units, to John W. Cowper, Constable Building. Estimated cost, \$100,000.

**NEW YORK**—The John Trager Steam & Copper Works, 447 West 26th St., has awarded the contract for the construction of a four-story concrete and brick factory, to Garret S. Wright, 415 West 24th St. Estimated cost, \$20,000.

**OTISVILLE**—The Construction Division of the War Department, Washington, D. C., will build an addition to its present laboratory in connection with the additional hospital facilities at the Tuberculosis Hospital here. Total estimated cost, \$312,573.

**YAPHANK**—The Construction Division of the War Department, Washington, D. C., has awarded the contract for the construction of a sewage disposal plant here, to the Beaver Engineering & Contracting Co., 51 Chambers St., New York City.

### North Carolina

**ANDREWS**—The Andrews Tanning Co., Lock Haven, Penn., recently organized with \$50,000 capital, will build an extract plant here.

### Ohio

**AKRON**—The Commissioners of Summit County received bids for the construction of a sewage disposal plant for Summit Co. Infirmary buildings, from Kovel, Walsh Construction Co., Akron, \$12,768; Herman House, Akron, \$15,102. D. Dovers, Akron, \$15,468. M. P. Laufer, 425 Ohio Building, engineer. Noted Oct. 31.

**ANCHOR**—The United States Government has awarded the contract for the construction of a nitrate plant at here, to the George A. Fuller Co., Swetland Building, Cleveland.

**ANCHOR**—The Air Nitrates Corporation, 360 Madison Ave., New York City, N. Y., will build the first unit of its new plant here. Estimated cost, \$20,000, the output to be used for government service exclusively.

**CLEVELAND**—The Grasselli Chemical Co., Guardian Building, will rebuild its two-story, 60 x 120 ft. factory, which was recently destroyed by fire. Estimated cost, \$50,000.

**CLEVELAND**—The Ohio Chemical Co., 1177 Marquette Road, will build a factory on a site it recently purchased. J. H. Shales, secretary.

**CLEVELAND**—The Ohio Metal Braketting Co., 909 Schofield Building, will build a one-story, 54 x 102 ft. factory. Estimated cost, \$50,000. Frank Smith, c/o owner, architect.

**WILLOUGHBY**—The Construction Division of the War Department, Washington, D. C., will build a medical building and additional barracks, etc., here, for the use of the Chemical Warfare Service. Total estimated cost, \$167,670.

### Oklahoma

**MIAMI**—The Ron-Ani Mining Co. will build a 150-ton concentration plant and is in the market for sludge and slime tables, crushers, rollers, hollers, wire mesh, drills, engine, air compressors, lumber, roofing and holsts. Estimated cost, \$50,000.

**MIAMI**—The Greenback Mining Co. will build a 200-ton concentration plant and is in the market for motors, electric wiring, sludge and slime tables, crushers, air compressors, conveyors, roofing, lumber, engine, jess, hollers, rollers and wire mesh. Estimated cost, \$50,000. T. C. Greenback, superintendent.

**ST. LOUIS.**—The Lucky Strike Mining Co., Miami, will rebuild its concentration plant recently destroyed by fire and is in the market for mill hardware, mill roofing, lumber, concrete, sludge and slime tables, engine, boilers, pipe, crushers, air compressors, conveyors, belt drives, ore cars, ore cars and track. Estimated cost, \$65,000. E. H. Austin, superintendent.

**TULSA.**—The City Commissioners will install an additional filtration plant and add sufficient facilities to handle from 6,000,000 to 7,000,000 gal. water daily.

## Pennsylvania

**FRANKLIN.**—The Franklin Quality Refining Co., Lambertson Bank Building, will build a new filter house at its local refinery. Estimated cost, \$100,000.

**MARIETTA.**—The Gilliland Laboratories Co. will rebuild its plant here recently damaged by fire.

**NOXEN.**—The Noxen-Armour Leather Co., Union Stock Yards, Chicago, Ill., has awarded the contract for the reconstruction of a two-story concrete and brick tanning plant to Westinghouse, Church, Kerr & Co., 37 Wall St., New York City, N. Y. Estimated cost, \$500,000.

**PHILADELPHIA.**—The Keystone Lubricating Co., 21st and Clearfield St., will build a 20 x 225 ft. plant to its plant for the manufacture of grease.

**SHARON.**—The Sharon Steel Hoop Co., South Irving Ave., will build two additional open hearth furnaces, a by-product coke plant and possibly another blast furnace.

**SWEDENLAND.**—The Rainey-Wood Coke Co. formed by the Allen Wood Iron & Steel Co. and the W. J. Rainey Estate of 52 Vandenberg Ave., New York City, N. Y., will build a byproduct coke oven plant to produce 1200 tons of coke daily for use in blast furnaces and large quantities of ammonium sulphate and other chemicals.

## Texas

**BURKBURNETT.**—D. B. Welty, Cushing, Okla., and associates, will build an oil refinery here having a daily capacity of 2000 barrels, upon site recently purchased.

## Utah

**SALT LAKE CITY.**—The Vipont Mining Co. will build a 250-ton concentration plant in the Ashbrook District of Boxelder County. C. A. Phillips, president.

## Virginia

**NORFOLK.**—The Bureau of Yards & Docks, Navy Department, Washington, D. C., will soon award the contract for the construction of an acetylene generating plant, oxy-acetylene and generating plant here. Estimated cost, \$110,000. Noted Oct. 31.

**RICHMOND.**—The Southern Oil Products Co., recently incorporated with \$50,000 capital, will establish a local plant and is in the market for machinery and equipment for the manufacture of oil specialties. The initial installation is estimated to cost \$10,000. W. H. Warren, 761 American National Bank Building, president.

## Washington

**PUGET SOUND.**—The Bureau of Supplies & Accounts, Navy Department, Washington, D. C., has issued bids for the construction of acetylene and oxy-hydrogen generating plant, Schedule No. 1553, Class 11, from Alexander Milburn Co., Baltimore, Md., \$900 (part bid); Burdett Manufacturing Co., 209 St. John St., Chicago, Ill., \$38,892; Davis Bourneville Co., Van Wagon Ave., Jersey City, N. J., \$42,128, alternate, \$38,897; International Oxygen Co., 115 Broadway, New York City, N. Y., \$44,117, alternate, \$53,175.

## West Virginia

**CHARLESTON.**—The West Virginia Water & Electric Co., 131 Summers St., has awarded the contract for remodeling and building additions to its existing plant, to the Charleston Concrete Construction Co., Charleston.

**MARTINSBURG.**—The National Shale Brick Co., recently incorporated with \$250,000 capital stock, will build three brick plants. Address H. H. Emmert, Martinsburg.

**WATSON.**—The State Board of Control, Clarksburg, will build a sewage-disposal plant here.

## Wisconsin

**MARINETTE.**—The Marinette-Menominee Paper & Pulp Co. has awarded the contract for the construction of a sulphite mill and two towers, to the Northern Boiler & Structural Co., Appleton.

**MILWAUKEE.**—The Modern Steel Treating Co., 223 Beecher St., will rebuild its plant recently destroyed by fire, entailing a loss of \$20,000.

**WAUWATOSA.**—The Northwestern Chemical Co., 61st and State St., has awarded the contract for the construction of a one-story, 48 x 147 ft. chemical plant, to C. A. Kleppe, 1026 1st St., Milwaukee. Estimated cost, \$20,000. Noted Oct. 15.

## Wyoming

**BIG SANDY.**—The Producers & Refiners Corporation, 101 California Building, Denver, Colo., will build a casing-head gasoline plant, having a daily capacity of 10,000,000 cu ft. on their property in the Big Sand Draw Field. T. G. Smith, of the International Trust Co., and California St., Denver, Colo., director.

## British Columbia

**GRAVES POINT.**—The Granby Consolidated Mining, Smelting & Power Co., 718 Groulx St., Vancouver, will build a by-product plant. Estimated cost, \$1,250,000.

**IOCO.**—The Imperial Oil Co. Ltd., Cambie and Smythe Sts., Vancouver, will build an addition to its oil refineries. Estimated cost, \$250,000. J. E. Sirdwan, superintendent.

**VANCOUVER.**—The Drum Lummon Copper Mines, Ltd., 115 Dominion Building, will install a Gibson mill and concentrator in its works at Drum Lummon Bay, Douglas Channel, to have a daily capacity of 36 tons. Estimated cost, \$5,000.

## Ontario

**TORONTO.**—The Palmolive Co. of Canada, 64 Natalie St., will build an addition to its plant. Estimated cost, \$10,000.

**WINDSOR.**—The British American Oil Co., Royal Bank Building, Toronto, will build a concrete and steel distributing plant. Estimated cost, \$150,000. T. S. Merrill, 25 Woodland St., Detroit, Mich., secretary.

## Industrial Notes

THE UNITED FILTERS CORPORATION, of Brooklyn, N. Y., have found it necessary to move to larger quarters. The Eastern works testing laboratory will be in its own building at 355 Cortlandt Street, Bellevue, N. Y., and the sales office is now located at 65 Broadway, New York City.

RICKETTS & Co., Inc., New York City, formerly of 80 Maiden Lane, announce that, in order to meet increasing business requirements they have found it necessary to move to larger offices at 280 Madison Ave. By associating with them Charles E. Wagstaffe Bateson, and Dr. M. L. Hamilton, and by securing the services of T. A. Shegog, formerly assistant professor of chemistry and metallurgy for the county of Monmouth, they have placed themselves in a position not only to carry on their mining and metallurgical consulting business on an enlarged scale, but also to handle the most varied organic and inorganic manufacturing problems and related chemical work. Small samples for assay or analysis should be placed in parcels post to the office, large samples by express to the laboratories, 7 Dutch Street, New York City.

THE LOCOMOTIVE PULVERIZED FUEL CO. has just received an order from Morris & Co., Chicago, Ill., for equipping its steam power plant at Oklahoma City, Okla., with a complete "Lopulco" system for crushing, drying, pulverizing and burning coal. Native coals are expected to be used in conjunction with Texas lignite. The power plant contains seven Edgemoor boilers, having a total of 3100 horsepower, all of which are to be equipped with the "Lopulco" system.

THE BARBER-GREENE Co. announces the strengthening of its organization as follows: F. E. Smith, chief engineer, formerly of the engineering department of the Stephens-Adams Mfg. Co., of the Granby Mining & Smelting Co., and the American Zinc & Chemical Co., Geo. C. Sanford, superintendent, formerly of the Elevator Supply Co., and of the Otis Elevator Co.

THE FEDERAL DYESTUFF & CHEMICAL CORPORATION OF KINGSPORT, Tenn., has decided to call itself the Union Dyestuff & Chemical Corporation.

## Manufacturers' Catalogs

THE W. S. ROCKWELL Co., 50 Church Street, New York, calls attention to two new bulletins. Bulletin 36 illustrates and describes filtering reverberatory melting furnaces for non-ferrous metals in capacities ranging from 500 to 2000 pounds. Bulletin 37 illustrates a type of furnace used for heating, purifying, and casting copper and similar products, without oxidation. Figs. 1 and 2 illustrate equipment in an Eastern wire mill; Figs. 3 and 4, an installation at a big copper mining company in Montana. Fig. 5, with the table attached, shows that it is self-explanatory. This installation was made in the West and while the results secured were very good, still it is expected that they will be greater, better, when the operators become more familiar with the furnace. Copies will be sent to any one who can use them to advantage.

THE PACIFIC TANK & PIPE CO., San Francisco, Calif.: A very attractive 123-page booklet, Catalog No. 12, illustrates and describes the latest improvements and ideas in cyanide plant equipment. Standard dimensions, capacities and weights of tanks which this company can furnish are given, together with the list price of each.

THE SOWERS MANUFACTURING COMPANY, Buffalo, N. Y.: Catalog IV covers the Dopp line of copper, nickel, and steam jacketed kettles, mixers, and vacuum pans, which are described and illustrated.

THE J. P. DEVINE Co., Buffalo, N. Y., has just received from the press three bulletins. Bulletin No. 101 illustrates and describes the patented Devine patented vacuum chamber dryers. Bulletin No. 106 deals with single and multiple effect vacuum evaporators, vacuum pans, distilled water, and vacuum pans. Bulletin No. 107 is on high efficiency vacuum pumps, both rotary and slide valve type. In these bulletins the illustrations are photographs showing actual installation of apparatus. Copies of these bulletins will be gladly sent to anyone interested in the types of apparatus described.

THE HANOVIA CHEMICAL & MFG. CO., Newark, N. J.: Announced a new bulletin, No. 20W, descriptive of the Hanovia Quartz Lamp, a scientifically designed and efficiently practical source of the ultraviolet rays, which are being successfully used in the chemical industry. The bulletin contains facts regarding some of the uses for the lamp and its adaptability.

## New Publications

TESTS TO DETERMINE THE RIGIDITY OF RIVETED JOINTS OF STEEL STRUCTURES: Bulletin 104, issued by the Engineering Experiment Station of the University of Illinois, Urbana, Ill.

MAXIMUM BITUMINOUS COAL PRICES, F. O. B. AT THE MINES. Publication No. 4E, published by the United States Fuel Administration, Washington, D. C. These prices were in effect Oct. 7, 1918.

NEW UNITED STATES GEOLOGICAL SURVEY PUBLICATIONS: 1.7, Tin in 1917, by Adolph Knopf; Mineral Resources of the U. S., 1917, Part I (pages 63-72), published Sept. 16, 1918; 1.8, Silver, Copper Lead and Zinc in the Central States in 1917, Mines Report, by J. P. Dunlop and B. S. Butler; Mineral Resources of the U. S., 1917, Part I (pages 73-120), published Oct. 24, 1918; 1.13, Fuller's Earth in 1917, by Jefferson Middleton; Mineral Resources of the U. S., 1917, Part II, (pages 253-255), published Sept. 18, 1918; 1.14, Coal in the Central States in 1917, by James M. Hill; Mineral Resources of the U. S., 1917, Part II, (pages 255-291), published Oct. 14, 1918; Bulletin 104, The Manufacture of Retort Coal-Gas in the Central States, Using Low-Sulphur Coal from Illinois, Indiana and Western Kentucky, by W. D. Perkins and W. W. Odell, is published by the State of Illinois, Dept. of Registration and Education, Division of the State Geological Survey, Urbana, Ill.

NEW BUREAU OF MINES PUBLICATIONS: Tech. Paper 139, Low-Rate Combustion in Fuel Beds of Hand Fired Furnace. By Henry Kreisinger, C. E. Augustine and S. H. Karp, Tech. Paper 136, Methods for the Determination of the Explosive Properties of Routine Work of the Bureau of Mines. By S. P. Howell and J. E. Tiffany; Tech. Paper 132, Production of Explosives in the United States During the War, 1914-1917, with notes on coal-mine accidents due to explosives and list of permissible explosives tested prior to April 30, 1918. Compiled by Albert H. Karp, Tech. Paper 131, The Tars Distilled from Bituminous Coal in Hand-Fired Furnaces. By S. H. Katz.



# CHEMICAL & METALLURGICAL ENGINEERING

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### The Reconstruction Conference To Be Held at Atlantic City

IN our last issue we called attention to the War Emergency and Reconstruction Conference to be held at Atlantic City on Dec. 4, 5 and 6. Now we urge our readers who are engaged in industries affected by the war to put in appearance if possible. It is a meeting of the 380 or more War Service Committees and the Chamber of Commerce of the United States, under the auspices of which it is called. These various committees have been consolidated into thirty-five groups which foregather separately on Dec. 4. Then they are merged into ten major groups which meet separately on Dec. 5 and in conclusion they come together for final action on Dec. 6. In the meantime a number of general sessions will be held in the Great Hall of the Million Dollar Pier at which eminent speakers will be present and make addresses. They will be open to the public.

A questionnaire containing twenty-five leading queries has been sent out by Mr. W. H. MANSS, director of the War Service Executive Committee, to all members of the War Service Committees. These cover a wide field and relate to definite problems such as unfilled orders for war materials, skilled and unskilled labor, financing, methods of canceling war orders, disposition of war materials, the continuation of the War Industries Board, control of materials during reconstruction, demand for finished products under peace conditions, raw materials, cost accounting, conservation, elimination of unnecessary products and wasteful practices, the requirements for the rehabilitation of allied countries and what we can supply until they are rehabilitated, the merchant marine, foreign competition, the Webb-Pomerene bill, etc.

The urgent need of careful and constructive thought on these and other matters is too evident to call for discussion, because legislation is certain, and if the leaders of industry do not agree upon plans we shall have to meet laws that are made without plans. With no disrespect toward Congress, we know that most of its members are lawyers, that very few of them are men of industrial experience, that sound economists are rare among them, that all must of necessity engage in politics, that politics addresses itself to what is called window-dressing—that is, to making the measures supported appeal to the popular fancy—and that industry has an entirely different task, which is to furnish the goods.

It is necessary, therefore, that whatever legislation is proposed be offered with good reason and that undue advantage for any industry shall not be sought at the expense of the general welfare. If it is, legislators



should not support it, and the best of them will not. On the other hand, if the measures proposed be conceived in a broad, patriotic spirit, with the general welfare of the people constantly in view, then politicians will vie with one another in coming to their support.

Many problems other than those involving legislation are to be considered, as those mentioned indicate. We cannot let them lie, thinking they will take care of themselves. If we do not look after them they will run away from us, and leave us stranded.

## A Grinding Problem

### That Crushed an Editor

LUTHER W. LENNOX contributed a very noteworthy paper to the Colorado meeting of the American Institute of Mining Engineers on the "Crushing Resistance of Various Ores," giving his method of obtaining a number which represents the relative difficulty in grinding rock. This factor is evidently so useful in the solution of various problems in reducing mill feed that the author received many well-deserved compliments on his neat and simple method.

One member pointed out, however, that the title was rather illy chosen, since the method compares the work necessary to reduce a 10-mesh feed, which operation the mill-man terms "grinding," reserving the word "crushing" to denote the operation of breaking mine-run to granules. Considerable merriment was provoked by Mr. Lennox's rejoinder that his original manuscript used the word "grinding" exclusively, but that the editor saw fit to change this word to "crushing" in each instance, despite his protest.

A conscientious editor naturally wonders how directly this pointed expression of disapproval applies to his own work. Men occupying the high literary places have so often expressed their disgust with the inelegant spoken and written language of the average American engineer that the technical man has almost come to accept their words at their face value. Very true, few engineers can write with Macaulay's clarity, Stevenson's absorbing interest, or Clemens' wit; but, indeed, where is the editor who can? And there is a lurking suspicion in the mind of the man on the job that the farther up in the clouds of literary expression the writer flies, the poorer his vision of the ordinary details of making the enterprise earn dividends!

Perhaps we editors are fussing too much over nomenclature; too much horrified at the split infinitive; insisting too strongly on our individual predilections for those intangible elements of "style." The other fellow's style may be as good as ours—a shiny boot, while correct for city wear, is a poor working shoe. When we rub elbows with the busy successful engineer with a coveted store of knowledge, our sins are visited on our own heads when he declines to put it on paper "because he can't write." Ten to one, if he would only dictate his thoughts to a stenographer in the abandoned way he would word a business letter, we would find so much meat in the effort that we would gladly thresh it into shape and put the finishing literary "polish" on it without which it would not pass acceptance, even though it might add only a little to the intrinsic merit of the contribution.

## Engineers Needed for Engineering Faculties

PERHAPS Dr. MANN's report on engineering education, recently published by the associated societies which instituted the investigation, will indicate to those responsible for our technical curricula the tremendous gap between those offered by them and those required by prospective engineers. Practicing engineers, at least, are keenly aware of the deficiencies in their own education and of those whom they employ, since early in the investigation an inclusive questionnaire brought out the fact that in their judgment the factors most important for success were of the following importance and rank: Character, judgment, efficiency, understanding of men, knowledge and technique. Speaking generally, it is unquestionable that our schools are spending the bulk of their effort on giving their students a kaleidoscopic acquaintance with engineering science and technique to the substantial exclusion of the four other vastly more important qualifications.

Engineering education is broadly defined by Dr. MANN as a means by which production can be increased. In order to improve engineering education in this sense, three things are needed: First, better students; second, better curricula; and third and doubtless most important, better instructors. The 60 per cent mortality among the student body is adequate proof that the admission requirements are fundamentally wrong—many pupils are passed through high schools to rid them of an overwhelming burden of ignorance. Too many of these boys and girls then enter higher institutions on the strength of their poorly earned standing, or by an examination which tests their ability to "cram." Little thought and effort are given to determine whether the man has the willingness and capacity, the moral and physical stamina to go the hard road leading to real achievement. Those lacking physical stamina and technique may infallibly be eliminated by observing a probationary performance at some laborious shop-work, but tests for capacity, ability and character are still being sought. It will take better faculties to find them and, after finding them, to apply them.

Better curricula are urgently needed. The present style is congested beyond endurance, is too often an engineering potpie, with a half-baked foundation and indigestible crust. As Dr. MANN points out, a correct plan demands that the time schedule be determined by subject matter essential to the equipment of the engineer, instead of the present opposite practice. It will require broad-minded comprehension of the prospective needs of engineers to determine the subject matter essential to the equipment of all engineers—"the common core" of engineering education—and in addition the subject matter essential for a specialist. It will require better men in the faculties, men who have a knowledge of engineering as written in books, but more—a knowledge of engineering as written in works.

Individually, one can find instances where nearly all the problems of scientific curricula-making have been solved. The point yet to be established is coördination. Coördinate and motivate the industrial, laboratory, scientific and humanistic work into a whole, appealing to the student as really worth while! Train him in the ability to perceive relationships between the value of a thing and its cost, between the humdrum of

daily work-routine and the underlying laws of nature, the principles of science and the human factors! As so defined, one is tempted to make the assertion that proper coördination in engineering schools is absolutely non-existent. It will take instructors of the highest class to institute it.

It has been clearly pointed out that in order to profit from the result of the investigation on engineering education the faculties and governing boards must be in sympathy with the new point of view. Respect for departmental autonomy must in some manner be overcome, the inertia of faculty meetings must be reduced, coöperation and coördination between the various departments of instruction must be absolute. Here again rises the ever insistent demand for a broad-minded, capable, enthusiastic teaching body, throwing their whole soul into the training of young men—that best work man can do—without the incubus of seniority, precedent and poverty which now frightens off so many good men. The governing boards who hold the purse-strings can thus do yeoman service in hastening the dawn of a new and better education, by providing the funds for the most essential requisite—a better faculty.

### Labor and Machinery In Iron Industry

ONE clear result of the war is a great increase in labor costs in the iron and steel industry. Unless the cost of machinery and equipment varies precisely as the cost of labor there is, obviously, a change in the relation between the two. When the relation stands at a certain level there is a point to which the introduction of "labor saving machinery," to use the common phrase, is advantageous, and beyond which it should not go. Every one recognizes, of course, that the "cost" of the machinery or whatever the equipment may be, when considered in this sense, is not the price that one pays for it, the cost in the abstract sense being a complex item involving first cost, current rate of interest on capital and whether or not a still better device may be developed within a short time.

There is good reason to believe that the changes that have been brought about by the war are such that the relation between the cost of labor and the cost of labor saving equipment has been altered to the disadvantage of employing labor and the advantage of employing machinery in the iron and steel industry. If so, there lies before the iron and steel industry an important period of improvement in the direction of displacing labor by machinery.

Incidentally, there is a contributing factor of no small importance, and that is that the tonnage capacity of the industry has grown so greatly that for a time there will be little disposition to increase capacity. As all going concerns are continually seeking to improve their position the talent they have will naturally be turned to the matter of improving the methods by which they turn out their present tonnage. In the past two or three years the case has been different. The object has been to increase tonnage the easiest way.

It might be argued that when there is a general advance in wage rates or a general advance in the cost of living, it affects everything more or less alike, hence the balance between the cost of employing a man and the cost of installing equipment to dispense with his

services has not been altered. The increase in wage rates and cost of living, however, has not affected all alike. The iron and steel industry occupies a peculiar position. Its common labor has been recruited very largely from the ranks of the foreign born, in other words it has depended chiefly upon immigration. The American born do not gravitate greatly towards employment at blast furnaces, coke works and steel mills. As to immigration, the statistics are simple and easily remembered. It is recognized that the rate varies according to industrial activity. The year ended June 30, 1913, was a very active one at iron and steel plants. The following twelvemonth was one of sharply decreasing activity. The statistics of the two years are therefore quite indicative of normal before the war. They showed, for aliens and citizens, a net movement into the country averaging almost precisely 60,000 persons per month. For four years July 1, 1914, to June 30, 1918, this movement would have involved 2,880,000 persons. The actual was about 280,000. Thus a "deficit" accumulated of about 2,600,000. In July, 1918, there were very few arrivals and many departures, making a net loss in population of 33,193. The departures were probably chiefly of civilians going abroad for war work, it is true, but recent surveys in the industry have disclosed a widespread intention of workers to go abroad, to hunt up relatives with whom connection has been lost and to scrutinize industrial and living conditions in their native countries in the changed conditions they have been told the war is to produce. A Connellsville coke producer made a canvass of his workmen with the following result: 25 per cent. intended to stay on the job; 25 per cent. intended to make a trip abroad; 50 per cent. intended to go abroad and stay there. Of course the men will not all do what they say they intend to do, but something of that sort is undoubtedly going to occur, and there will not be much immigration to balance.

The position of the iron and steel industry is that its common labor is of one class, while the labor used in making the appliances it buys is largely of another class. The supply of the former is depleted more than the supply of the latter. The changes due to the war do not increase the cost of the machine as much as the cost of the man.

The average of all wages in the United States is likely to come down from the level existing at the close of the war, but common labor in the iron and steel industry is not likely to come down as much as the general average. There is even a possibility of the rate per hour increasing. Taking the standard rate at 42 cents an hour, the 12-hour man, with the "eight-hour basic day" is paid for 14 times this for 12 hours' work, so that the cost to the employer is 49 cents an hour. If the supply of men willing to work 10 or 12 hours a day becomes insufficient the answer is not to increase the hours of labor per man, but to make conditions such that additional men will be invited to seek the jobs. That may mean the introduction of the universal eight-hour shift, for as a rule the shift period must be a divisor of 24, and the wage rate may be higher than 42 cents an hour, or even 49 cents. It is certain that the ratio between iron and steel labor and labor in general has been increased, and that means that labor saving devices are worth more than formerly.



## The Glory Of the Peanut

Time was when we considered it a measure of distinction or importance for a person or thing to occupy space in the *Encyclopædia Britannica*; the more space, the greater the importance. The peanut is not mentioned in it. The *Standard Dictionary* gives an illustrated inch to it and announces that peanuts are beans on the ground that they are leguminosæ.

It is a lowly subject. On the railroad a peanut train consists of not more than two cars; as soon as the third is added the train becomes a "local." Those who engage in peanut politics are sometimes also referred to as small potatoes. Large potatoes have dignity, but no variety of peanuts achieves this rank either in literature or in colloquial speech. Nevertheless, these are days of democracy, and we demand that the world be made safe for it, so that the humble be made great. And just as some of our most cherished institutions such as monogamy, co-operative industry, the establishment of groups of states, paper-making and a thousand other manifestations of wisdom and ingenuity have been developed for us in insect, bird and other animal life of lower order than our own, so those things which we have scorned in days gone by are now achieving aristocracy in commerce and growing potentiality by leaps and bounds. Knick-knacks at five and ten cents each have built the tallest and handsomest office building in the world. The humble banana still retains its post on the street corner, now under Greek rather than Latin auspices, and since it has entered the portals of commerce as fruit, the ships to carry it have almost become the leaders of the tropic seas.

Holding its own along with the banana and still giving its name to the stands from which it is sold, the peanut abides, setting an example in literary culture which we have long been commending to the youth of our land; the more diligent study of Greek, with its vast wealth of literature, in the place of Latin. We offer the peanut in its shifting from Latin to Greek as a worthy exemplar to our authorities in education.

If sulphuric acid represents industrial advancement, why should not peanuts represent advancement in democracy? We mean true democracy, intelligent, cultured and constructive democracy, and not the anarchy of hate which we find among the Bolsheviks. They do not eat peanuts—and behold their madness and rage and destruction! The Germans developed their Kultur without the aid of peanuts, and they, too, have gone mad and the walls of their temple are falling in upon them and crushing them.

The peanut has always been striving to rise. We recall an estimable merchant, surely long since gathered to his fathers, who entered the Boston & Maine trains at Salem, Mass., many years ago, carrying a generous basket upon his arm and calling out, "Peanuts, peanuts; fresh roasted peanuts; five AND ten cents a bag." The ten-cent bags were triple the size of those sold for five cents. He was an honest merchant and gave good measure. It was only the buyer, however, or those seated near him who discovered the good man's desire to adjust his wares to the greatest measure of human consumption—and consequent betterment. We venture to suggest that this may have come from his association

with peanuts. A nod of the head or a raised finger brought him to attention and service, and as he lifted the cover of his basket he displayed three separate compartments. Then he would inquire, "Low, medium or high roast?" and whoever could not be satisfied with such peanuts was a churl indeed. We preferred the high roast, but that was a matter of taste. The dealer, who was a busy man and indisposed to enter into idle conversation, favored the low roast, owing to the superior quality of the nut he offered for sale. Despite the *Standard Dictionary*, he never referred to his wares as beans. And he certainly knew peanuts.

Early in the '90s we recall occasional negotiations with a corporation which was popularly described as the Peanut Trust. It flourished chiefly in Virginia, but extended its operations also into North Carolina. We do not know whether it still exists, and we mention it merely to show the peanut ambition, which is not a thing to be scorned. Everything important in the United States was being organized into some kind of a trust. Early in the game, peanuts were on hand—and organized.

Now observe the rise of the humble goober following the research of the good Sabatier and the scramble for patents to profit by his discovery. Before the war this country produced about three and a half million bushels annually. In 1916 production rose to 40,000,000 bushels. In 1917 we devoted 3,277,000 acres to its cultivation; and its crops are bountiful. This year Texas alone has 3,000,000 acres growing peanuts with the prospect of a bumper yield.

It has robbed the boll weevil of its injury, for the vine is hardy against it, and the farmer who erstwhile raised cotton only to see his fields destroyed now raises peanuts and buys Liberty bonds. It has shaken the foundations of the Temple of Scarcity which the hog built for itself, because its excellent oil, hardened into fat by hydrogenation, supplies humanity's need for butter and lard wherever ships can carry it. Thus, also, it eases the burden of the over-worked cow.

In addition to the peanuts that we grow and notwithstanding the difficulties and expense of shipping, our imports of peanut oil have increased six-fold since the war began and now reach over 8,000,000 gallons. If the Germans had offered Alsace and Lorraine back to France by way of honorable exchange, they could have received a generous portion of Northern Africa in return, and Northern Africa is a veritable paradise for peanuts. And the war might have been avoided because the Germans would have had their minds on something else. Then they would still be respected among men and every decent club and social organization would not be closed to them. Right here is where we see the subtle relation of peanuts to beans which is declared by the *Standard Dictionary*—a pretty good book, after all. The Germans didn't know beans in the large, true and catholic sense. They didn't know peanuts.

A new concept of measurement is added to human understanding. We have gaged the development of industry by statistics of sulphuric acid, of progress by steel and of civilization by soap. Now let us add the measure of democracy by peanuts.



## Readers' Views and Comments

### Measurement of Odors

*To the Editor Chemical & Metallurgical Engineering*

SIR:—The writers have read with much interest the letter of Mr. V. H. Gottschalk, which was published in the Nov. 15 issue of your esteemed journal, concerning our paper, "An Investigation of Stenches and Odors for Industrial Purposes," read at the Cleveland meeting of the American Chemical Society.

Evidently Mr. Gottschalk did not hear the paper read, and your reporter has been overly kind in crediting us with priority, which Mr. Gottschalk shows we have not deserved. No claims for priority in measurement of odors were made by us, although we were not aware of other work of the same nature; also we named our apparatus an "odorometer," and not "odometer," as Mr. Gottschalk prefers. These discrepancies are due to reportorial error which will be evident as soon as the paper itself appears. We have noted since this question has arisen that the Standard Dictionary defines the word "odorimeter."

It is gratifying to see the interest which our paper on this subject creates, and we are indebted to Mr. Gottschalk for bringing to our attention previous work which has been published. We agree that the subject is one which deserves much further study. For the present the data which we are publishing are all that are needed by the Bureau of Mines to serve its purposes. It may be that other work will be done at some future time, but for the present, at least, it is ended. For this reason we will turn the matter over to other investigators, hoping that the work will receive further impetus.

Pittsburgh, Pa.

S. H. KATZ,  
V. C. ALLISON.

### Help for the Gold Producer

*To the Editor of Chemical & Metallurgical Engineering*

SIR:—I have read with much interest your editorial of Nov. 1, "Help for the Gold Producer." I think the statement may safely be made that the currency situation is, next to the war, the most important problem that confronts the world. It is remarkable that the present state of unreality of our monetary standard is not more widely known and discussed than is the case. We are no longer on a gold basis, and, far worse, we are not even on any other definite, even if depreciated, basis. There is therefore nothing binding us to terra firma, and anything is possible with respect to inflation of prices. Already the stoppage of redemption of currency in gold and of international shipments of gold to adjust balances has resulted in expropriating from the widows and orphans et al. 20 per cent of their capital (American exchange is, or recently was, at about 20 per cent discount in countries still remaining on a real gold basis), but this is a small matter compared with what may happen yet.

As to the remedy, it is easy to say that all that is necessary is to get back to the gold basis. This, assuming it to be possible, would not remedy the rise in prices in so far as that is due to the depreciation in the value of gold—that is inevitable, although many

observers believe the pendulum is about to swing the other way—but it would get us back to earth again.

While we have cut loose from the gold basis so far as making payments in gold and gold-demand currency is concerned, we refuse to pay the gold producer more for his product than formerly; that is, he gets a dollar currency for a dollar gold. What else is possible? To do otherwise would be a contradiction in terms so long as gold remains, even nominally, the basis of currency. You justly observe that to pay a bounty would be equivalent to raising the price of gold, but it may be added that there is no way the price of gold could be raised except only by paying a bounty. To pay \$1 +  $x$  for \$1 gold (23.22 grains) would be a bounty, pure, simple and undefiled.

There is an apparent attractiveness about anything that will "raise the price of gold" because we have always understood that a rise in the price of gold is another way of saying a fall in commodity prices.

One thing stands out, namely, that there is a certain grim humor in any criticism of the gold producers for not being able to suggest a feasible way out of a situation which, as present legislation stands, presents the same difficulties as does lifting oneself by one's bootstraps. In saying present legislation I mean that immediate relief would be given the producers if they were allowed to ship their gold to Spain, for instance, and, with the proceeds of its sale, buy American exchange.

ERNEST A. LE SUEUR.

Ottawa, Ont.

### Analyzed Samples Wanted

*To the Editor of Chemical & Metallurgical Engineering*

SIR:—We are building up a collection of analyzed samples of raw materials, intermediate and finished products of our typical chemical industries, and expect to use these specimens as practical material in our courses in quantitative and technical analysis.

It has been our experience that the work in analytical chemistry is greatly strengthened by the use of such material, but at present the time of most instructors is too occupied to devote the time necessary to make the analyses required to check the results of the students. The laboratories of many of our chemical manufacturers make such analyses as a matter of routine, and it would be a very helpful method of coöperation if they could turn over to use and to other universities laboratory samples together with their analytical data on the same. You have advocated a closer coöperation between the manufacturers and the universities and it appears to me that here is a chance for a definite service involving little extra work on the part of the works' laboratory forces. Samples of one to two pounds are sufficient for a year's supply, and different samples of the same material are useful in diversifying the work of different students of the same class. We shall be glad to pay transportation charges. The standard samples issued by the Bureau of Standards are too expensive for general use and their range is too limited. R. E. OESFPR.

Department of Chemistry,  
University of Cincinnati,  
Cincinnati, O.

## Western Chemical and Metallurgical Field

### Development of the Metallurgy of the Cripple Creek Ores

AMONG the many pleasant features of the recent Colorado meeting of the American Institute of Mining Engineers was a trip to Cripple Creek. The committee in charge followed the commendable plan of issuing a booklet describing briefly the notable features of the excursion, included in which was the following brief historical note on the metallurgy of sulpho-tellurides.

The first method adopted for local ore treatment, as has been the case in many other districts producing precious metal ores, was the stamp battery and plate amalgamation. During 1892 and 1893 ten stamp mills, with a total of 270 stamps, were erected. Although much of the gold from the surface ores occurred in a free state, it was soon proved that amalgamation was inefficient, due to the rusty nature of the gold. Concentrating tables and blankets were added to increase gold recovery, but even with these additions the extraction was low. Recovery became less and less as more of the unoxidized sulpho-tellurides were encountered, and stamp milling was soon entirely abandoned.

The first chlorination plant was built in the district by Edward Holden in 1893. Charles M. MacNeill was mill superintendent, and it was at this plant that D. C. Jackling secured his first position as assayer after walking into camp from Divide. From this time on various processes were tried for treating these ores, some fifteen mills in all being built. All of these were failures.

In 1895 a well-designed chlorination plant was built at Gillette under the supervision of J. Dawson Hawkins. This mill embodied all the improvements in chlorination known at that time. In 1897 the first cyanide mill (Brodie mill) was built at Mound City, under the direction of Philip Argall, following an earlier plant constructed in 1895 for the Metallic Extraction Co. at Florence. In 1896 and 1900 respectively Messrs. MacNeill, Penrose & Tutt built the Colorado & Philadelphia Chlorination Plant and the Standard Mill at Colorado City. Work was begun upon the Portland chlorination plant in 1901 and after operating as a chlorination plant for ten years following its opening in June, 1902, it was converted into a cyanide plant in 1912. In 1902 the Telluride Reduction Co. built a mill at Colorado City, employing bromine instead of chlorine; this was later converted into a cyanide plant, but finally failed in 1905. Philip Argall remodelled the plant, after it had been closed down for five years, into what is now known as the Golden Cycle Mill, and under the more recent management of A. L. Blomfield this has been developed into a highly efficient cyanide plant. Following the success of the chlorination mills built at Colorado City, the Union Chlorination Plant and the Dorcas Cyanide Mill were built at Florence.

From the first discoveries until recent years much of the ore produced in the Cripple Creek district has been shipped. After the first attempts at local milling, all of the higher-grade ore which was not smelted has been milled at plants located at Colorado City and Florence. Treatment of the ore outside the district continued un-

til the building of low-grade mills by Stratton's Independence, the Portland and the Vindicator companies. The development of successful processes for the local treatment of low-grade ore which could not stand the expense of shipment has been an achievement of the first order. This development has rendered profitable many of the waste dumps and large bodies of low-grade ore left standing in the mines, thereby greatly prolonging the life of the camp. Through persistent research and able business management the low-grade complex ores of the district are as efficiently treated as simpler precious metal ores occurring elsewhere. During 1907-8 a number of small plants were built for the cyanide leaching of coarsely crushed surface oxidized ores. The plants met with a greater or less degree of success, but at best were short lived on account of the limited quantities of ore available suitable for this treatment.

In 1908 Philip Argall erected and began operating the Independence Mill, using a combination of concentration and cyanidation. The same year, after extensive investigation, the Portland company erected the Victor Mill, which was placed in operation five months later than the Independence Mill. Shortly after the flotation process had proved successful upon various base metal ores in the United States the Portland company began investigation of the treatment of Cripple Creek ores by this method. After giving the process a thorough trial on a large scale it was finally abandoned in favor of the cyanidation, as formerly practiced. In 1916 the Vindicator company (the first to operate a flotation on a large scale in the district) built its present mill, which has since been continuously and profitably operated.

The chlorination process as practiced upon Cripple Creek ores was the barrel process as developed in the Black Hills from the crude barrel process used in South Carolina. Many improvements were made, and eventually it was operated upon a far larger scale than ever had been attempted in the Black Hills. For years there was a struggle for supremacy between the chlorination and the cyanide processes, each having very strong advocates. Up until the conversion of the Golden Cycle Mill to a cyanide plant the bulk of the higher-grade ores not shipped to smelters were treated by chlorination. Following the successful demonstration of the process at this plant, the Portland chlorination plant was converted to cyanide and the chlorination mills at Colorado City and Florence were closed. The two metallurgical developments which gave cyanidation the advantage were fine grinding and the introduction of efficient methods of slime treatment. It is of interest in passing to note that practically all the old chlorination tailing has been re-treated by the cyanide process at a profit. At present the Colorado Springs cyanide plant of the Portland company is closed, and this company is doing all of its milling at the mine, while the Golden Cycle Mill is the only mill now operating outside the district.

The cyanide process, as at present developed for the treatment of the higher-grade Cripple Creek ores, consists of coarse crushing in rolls or comminutors, followed by roasting in Edwards, Pierce-Turrett or Holthoff furnaces. After roasting, fine grinding is accomplished in either tube or Chilean mills. The product is either treated by straight agitation and filtration or, after separation of sand and slime, the sand is leached and the slime treated by agitation and filtration.



## Size vs. Recoveries in Ferromanganese Furnaces\*

BY E. S. BARDWELL

Metallurgist, Anaconda Copper Mining Co.

RECENT observation of a number of electric furnaces varying considerably in size and transformer capacity, and all working under the same conditions, shows the small furnaces to be much more efficient in operation than the large furnaces.

The furnaces examined were all of the same type. The crucibles consisted of tanks varying in size from  $7\frac{1}{2}$  x 15 ft. x  $4\frac{1}{2}$  ft. deep, to 12 x 20 ft. x 9 ft. deep, with linings formed of carbon electrode butts. The smaller furnaces had transformer capacity rated at 1500 kva.; the largest furnace had a transformer rated at 3000 kva. All of the furnaces were operated on 3-phase, 60-cycle current, the three electrodes being in a straight line. The voltages varied from 65 volts in the smaller to 100 volts in the larger furnaces. The charges consisted of manganese ore, coal, iron turnings and limestone in proper proportions.

The small furnaces, operating at low voltage, were making good recoveries. The slag loss was low and the volatilization loss almost nil. The larger furnaces, operating at higher voltages, showed increased loss of manganese in the slag and greatly increased volatilization loss when working on the same charges as the smaller furnaces or on charges similarly calculated.

The exact reasons for this state of affairs are difficult to state; a number of factors probably contribute to the results obtained in the large furnaces. First as to the effect of the higher voltage on manganese content of the slags. Increasing the voltage of the furnaces apparently tends to promote irregular working. The current takes the path of least resistance; this means superheating in certain areas in the crucible and insufficiently high temperatures in adjoining areas. The partially reduced manganese in the cooler areas passes into the slag and escapes further reduction.

As to the effect of the higher voltages on volatilization losses, it is clear that the result of the excessively high local temperatures will be to augment volatilization. Furnaces operating at the higher voltages are also subject to the formation of accretions consisting of carbide and graphite, which tend to form with an excess of carbon. The formation of carbide robs the charge of a portion of its lime, rendering the slag composition very different from that calculated and desired. The electrodes are forced up, and volatilization is still further increased. The presence of carbide and graphite in the furnaces working at the higher voltages points to the existence of higher temperatures in these furnaces than in those operating at lower temperatures. The small furnaces rarely show signs of accretions, although both carbide and graphite are formed in them to a limited extent.

The advantages to be gained from having a large unit are obvious, although there is much to be said in favor of a number of smaller units. Assuming for the moment that a large furnace is desired, let us consider the

voltage to be employed. It is evident that the large furnace possesses no advantage over the small furnace unless we can get proportional or more than proportional production from it. Output, of course, is dependent on power input. If we represent the current by  $I$ , the voltage between phases by  $E$ , and the reactance and impedance by  $X$  and  $Z$  respectively, we may write the following equations:

$$I = \frac{E}{\sqrt{X^2 + Z^2}}$$

$$Z = \sqrt{X^2 + R^2}$$

$$\text{Power input} = I^2 3 EI_p$$

where  $p$  is the power factor.

Examining the first equation, we see that the current input may be increased either by increasing  $E$  or by decreasing  $Z$ . Experiments have shown that in any given furnace the reactance,  $X$ , is a constant for all except the very lightest loads; hence any decrease in the resistance, according to the second equation, will result in a decrease in the impedance and a corresponding increase in the current and power input.

The resistance of the charge may be decreased by substituting coke for a part or for all of the coal. If this is done, and if the voltage be kept reasonably low, it should be possible to obtain increased power input and steadier operating conditions than are obtainable on the higher-voltage furnace.

R. Korten<sup>1</sup> gives some interesting data regarding the melting of ferromanganese in the electric furnace, particularly in the Keller furnace. He states that melting without loss of manganese by volatilization is most certain if low voltage is employed, that the arc must be short, and the hearth offer as large a surface as possible. A uniform heating over a large surface and not an intense heating over a small surface should be sought.

While conditions are not exactly the same in electric furnaces for the smelting of manganese ores, my experience has been that better results are obtained where low voltages are employed and when the power input is properly proportioned to the size of furnace employed.

When treating Montana carbonate ore containing 36.8 per cent Mn and 6.79 per cent  $\text{SiO}_2$ , using coal as reducing agent and marble as flux, it has been found possible to keep the slag loss below 3 per cent of the manganese in the ore. The average slag analysis over a period of a week was as follows: Mn, 4.26;  $\text{SiO}_2$ , 34.37;  $\text{Al}_2\text{O}_3$ , 7.93; CaO, 44.83; MgO, 4.10; BaO, 0.88 per cent.

This result is extremely good when compared with the slag losses quoted by Mr. Keeney, which vary from 12 to 25 per cent. Results like the former are easy to get in small furnaces working at low voltages. I feel confident that we shall be able to duplicate them in large furnaces after sufficient study.

The greatest problem yet to solve is the reduction of the volatilization losses. We know that it is possible to keep this loss low in the small furnaces, and doubtless a more thorough understanding of furnace conditions will enable us to solve the problem in the case of the larger units.

Great Falls, Mont.

\*Discussion of the paper of Robert M. Keeney, presented at the Colorado meeting, September, 1918.

<sup>1</sup>*Stahl und Eisen* (March 14, 1912) 32, 426.



## Atlantic City Meeting of War Service Committees

A WAR Emergency and Reconstruction Conference will be held at Atlantic City, N. J., during the week of Dec. 2, under the auspices of the Chamber of Commerce of the United States. Mr. Horace Bowker, president of the Chemical Alliance, Inc., will be chairman of Major Group No. 7, on Chemicals.

Preliminary conferences of the representatives of the 380 war service committees will be organized Monday and held Tuesday. Double sessions at 10 a.m. and 2.30 p.m. will be held at the Million Dollar Pier on Wednesday and Friday. Wednesday evening the 35 minor groups will meet at 8 o'clock. Thursday, at 10 a.m. a general session will be held, and at 2.30 and 8 p.m. the 10 major groups will meet separately.

### MAJOR GROUPS

1. Food Products
2. Heat, Light and Power
3. Iron and Steel
4. Metals and Minerals Other Than Iron and Steel
5. Textiles
6. Wood and Wood Products
7. Chemicals
8. Leather
9. Earthen Products
10. Industrial Professions.

### QUESTIONS TO BE DISCUSSED

1. What legal methods or means could be introduced in the craft to better stabilize prices, during the reconstruction period, affected by the following:

- a. Inventories on hand.
- b. Orders placed at war prices but not delivered.
- c. Labor costs and conditions.
- d. Increased taxes.
- e. Increased rates of interest.
- f. An estimated increased demand for non-war materials restricted during the war period.
- g. Will an increased production of your commodity increase the price of material or labor, or will a controlled redistribution of material and labor from war industries prevent such an increase?
- h. Discuss the practice of the sale of commodities at a price less than the cost of production. Its injury and disturbance on the industries and the ultimate consumer. What methods would you suggest to remedy this evil?
- i. If the Government sees fit to dispose of used materials and products in the open market, what effect will it have on your production and the sale of new goods? At home? Abroad?
- j. If it is not advisable for the Government to sell these goods on hand, either home or abroad, what shall it do with them?
- k. In this connection, what point of contact should business interests have with the governmental departments in the sale or disposition of these various commodities?

2. What is the estimated amount of labor, skilled and unskilled, male and female, required for the estimated 1919 production? What is to be the source of labor? How much must be moved? How much have you lost to war industries?

3. What is your financing problem during the reconstruction period? Do you recommend governmental aid? Is financial legislation needed? Should the Capital Issues Committee be continued during this period?

In this connection discuss and recommend what financial obligations, if any, the industries in your craft are under to the Government for moneys advanced for buildings, machinery or as loans or security for Government contracts. How are these to be liquidated or adjusted?

4. What method would you suggest for the cancellation of Government war orders with your craft that would create the least amount of hardship on the industries and permit a readjustment to normal commercial conditions?

5. On undelivered Government orders, what percentage of materials on hand, supplied either by the Government or purchased by you for these Government orders, can be utilized by your craft for commercial purposes during 1919? What disposition shall be made of those not usable?

6. Have you any suggestions to make as to the continuation

of the War Industries Board or any of its divisions, or any other governmental departments during the period of reconstruction? Such board or departments to have the authority to control materials and regulate prices. If so, for what period?

7. What intelligent control of materials during the reconstruction period could the War Service Committee suggest which would prevent an over or under supply and avoid a demoralization of the market? Should this be controlled by the crafts or by a governmental agency?

8. What effect had the war program on your output? Was it increased or decreased? Will there be an increased demand during the reconstruction period? If materials are uncontrolled will prices go up or down?

9. What is the estimated tonnage or unit of production of your raw materials for 1918? For 1919? Estimated demand for foreign commerce for 1919?

10. What is the estimated demand for your finished product for 1919? How does this compare with the average demand per annum in weight or unit of production for a five-year period immediately prior to 1914?

11. Sources of your raw materials? Domestic or imported? If domestic, can railroad cross-hauling be eliminated by purchasing nearer your plants? Causes of cross-hauling? If imported, at what ports? Would other ports of entry be more advantageous? What ports and why?

12. The value of a uniform method of cost accounting for the individual manufacturer and the craft as a whole.

13. What suggestions of the Conservation Division made to your craft might, with financial profit to your craft, be continued during the readjustment period? Is it possible to maintain a conservation schedule after the war, without legislative authority?

14. What methods and practices, other than those your craft has already introduced, would simplify production, save materials, eliminate wasteful practices, reduce the number of styles, without destroying individual creativeness?

15. What propaganda is necessary to educate the retailer and consumer to accept these eliminations and simplifications, and what plans might be arranged for better functioning with committees of jobbers and retailers handling your commodities?

16. What percentage of the commodities represented by your War Service Committee was produced in the United States before the war and what percentage imported? What suggestion have you to make for increased production for domestic and foreign commerce?

17. What effect will foreign competition have on your business? Will it increase or decrease your production?

18. What is the underlying reason for the importation of foreign-made goods: Prices? Styles? Label? Quality? Design? Or excess demand over domestic supply?

19. What disposition should be made by the Government of her merchant marine?

20. What steps have you taken, or do you propose to take, for the entire craft to take advantage of the Webb-Pomerene Bill, which allows combination for foreign trade, or have you other plans? What do you suggest as the best means of financing foreign credits? What percentage of the foreign commerce heretofore controlled by Germany can your craft obtain and supply?

21. What study is necessary, and what suggestions have you to make, in order to determine what are the needs of our allied countries for rehabilitation, and how far can you supply both raw and finished materials until they have been rehabilitated?

22. Has your craft been solicited by, or are you soliciting, foreign countries to supply these materials for rehabilitation purposes? If solicited, does this come from the Allies, or from neutral or enemy countries?

23. Would you recommend the appointment of a committee of United States manufacturers to confer with similar committees from our allies, to learn of their plans for protecting industry during the reconstruction period? Also to obtain information regarding commodities and supplies needed by them and ourselves during this period?

24. When the demobilization of military forces takes place, how can these men best be returned to their former industrial pursuits, and how will it affect your labor situation?

In this connection, how closely should the Conference work with the governmental bodies in the study of demobilization plans?

25. What suggestions have you to make to encourage and stimulate public work, such as the building of roads, pavements, water and sewer extension, the construction of public buildings, school houses, etc.? What effect will it have on the labor market?

In this connection consider the building program in the United States and especially the utilization or destruction of new plants built for war purposes. Location of convalescent and reconstruction hospitals near industrial centers so that these men can be trained in the factories nearest to the hospitals without creating new vocational schools.

System of Radio-active Elements

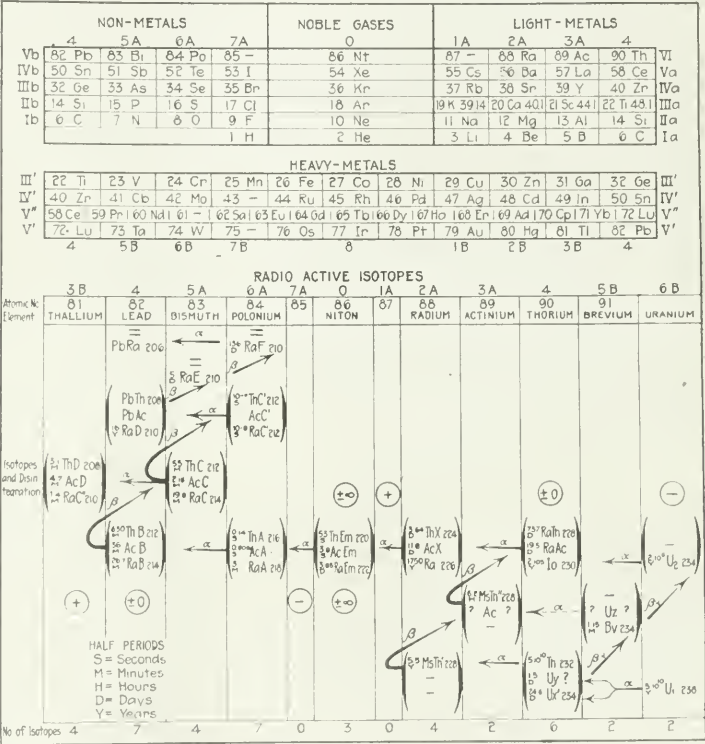
By INGO W. D. HACKB

TWENTY years ago saw the birth of a new science, the discovery of the radio-activity of thorium by G. C. Schmidt, Becquerel and Mme. Curie in 1898. Since that time we have witnessed a steady and gradual transformation in our conception of matter and new avenues have been opened for experimental investigation in many fields of physics, chemistry and biology. To-day we know of three series of radio-active substances, uranium, thorium and actinium series, which include about forty definite substances. Much work has been done to classify these forty radio-active substances and to establish their relationship to the periodic system of the chemical elements. Among the numerous publications on radio-activity and periodic system are those of van der Broek<sup>1</sup>, Cameron<sup>2</sup>, Meyer<sup>3</sup>, Russell<sup>4</sup>, Fajans<sup>5</sup>, Soddy<sup>6</sup>, Hönigschmidt<sup>7</sup>, Venable<sup>8</sup> and others. Thus the connection between the chemical elements and the radio-active substances is fairly well established. Investigations on the high-frequency spectra or X-ray spectra of the elements furnished the so-called atomic numbers of the elements, beginning with H 1 and ending with Uranium 92, thus giving us a continuous series of 92 elements (of which 5 elements are not yet discovered) with increasing atomic weight. The elements of atomic numbers 81 to 92, that is, those elements of highest atomic weights, show radio-activity, and the conclusion is, therefore, that the atom of such an element has become unstable and disintegrates, that is, breaks up by forming "elements," resp. isotopes, of lower atomic weight.

This integration or transmutation from an element of higher atomic weight to one of lower atomic weight takes place spontaneously at a definite period of time. This definite period is characteristic for each radio-active substance and is usually expressed in the "half-period," that is, the time required for the decay of one-half of any amount of a radio-active substance. This period is unchangeable and can at present not be affected by any physical and chemical means which our present knowledge offers. The disintegration takes place in two ways, according to two characteristic forms of transmutation, namely, the alpha-ray transmutation and the beta-ray transmutation.

The transmutation which is caused by the emission of alpha-rays lowers the atomic weight by 4 and the valency by 2 and makes the element more electro-positive. Alpha-rays are deviated by the magnetic and electric field and consist of positively charged nuclei of helium, traveling at a speed of about one-tenth the velocity of light and having a high power of ionization but small capacity of penetration, and are therefore quickly absorbed by the different media. They are of the type of the canal rays.

The transmutation caused by the emission of beta-rays makes the element more electro-negative, increases the valency by 1 and the atomic weight remains the same. Beta-rays are deviated by the magnetic field and consist of negatively charged electrons, having a speed of two-



THE HACKB PERIODIC SYSTEM WITH FLOW SHEET OF THE RADIO-ACTIVE ISOTONES

fifths to nine-tenths the velocity of light and possessing little power of ionization but high capacity of penetration. They are of the type of very fast cathode rays.

The gamma-rays are the secondary effect of the beta-rays, and can be compared with very hard X-rays, that is, they are produced by the impact of beta-rays (cathode rays) upon solids.

By the work of Ilievsky<sup>9</sup>, Fleck<sup>10</sup>, Metzner<sup>11</sup>, Fajans<sup>12</sup>, Klemensiewicz<sup>13</sup>, and others it has been found that the chemical nature of some radio-active disintegration products is similar to certain elements, and their experiments therefore confirm the evolution of the elements through the periodic table. Ordinary lead (atomic num-

ber 82) would, for example, consist of the following "isotopes":

|      |                  |                |
|------|------------------|----------------|
| PbRa | At. weight 206.2 | no radiation   |
| PbTh | At. weight 208.2 | no radiation   |
| PbAc | At. weight ?     | no radiation   |
| RaD  | At. weight 210.2 | beta-radiation |
| ThB  | At. weight 212.2 | beta-radiation |
| AcB  | At. weight ?     | beta-radiation |
| RaB  | At. weight 214.2 | beta-radiation |

and its atomic weight of 207.2 would be the average of the different isotopes and is dependent upon the period of these isotopes. In fact it has been shown by Mme. Curie<sup>1</sup>, Richards and Lambert<sup>2</sup> and others that the atomic weight of lead from different sources differs, and may range from 206.40 to 207.15, according to the minerals used.

In the lower part of the accompanying table, the different radio-active isotopes are placed under one another, while the radio-active disintegration is indicated by the arrows. It will be noticed that, with the exception of the first and last members of the uranium series, the disintegration of the three series follows the same course, and we have therefore triads of isotopes. The connection of the actinium series to the uranium series is not clearly established; lately Carruthers<sup>3</sup> and van den Broek<sup>4</sup>, by plotting certain radio-active constants, come to the conclusion that actinium should branch off from U, instead from U<sub>2</sub>, as shown in the table.

The periodic table as shown differs from the customary table in some respects. It enables a better classification of the elements into the three groups of non-metals, light metals and heavy metals. Each of these groups can be subdivided; for example, the "Light Metals" include group

1A—the alkali metals

2A—the earth-alkali metals

3A—the earth metals

while the carbon-group forms the transition points of these different groups. The table has been fully described elsewhere<sup>5</sup> and the connection of the elements with the isotopes can easily be seen.

The writer hopes that this table may serve not only as a better illustration of the disintegration of radio-active substances, but also as a clearer and more compact representation of the periodic system.

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## Radium and Radio-activity

AT THE first regular meeting of the New Jersey Chemical Society, held at the Technical School in Newark, N. J., Nov. 11, 1918, Dr. Charles H. Viol presented an address on "Radium and Radio-activity." In discussing the modern conceptions of radio-activity, radiant energy, electrons, isotopes, atomic disintegration and the transmutation of metals, Dr. Viol said:

"To date there has been produced in the United States a total of nearly two ounces of radium in the form of finished material of high purity, and of this total one and one-third ounces (37 grams) have been produced in the Radium Research Laboratory of the Standard Chemical Co. of Pittsburgh. The U. S. Bureau of Mines has for a number of years been waging a propaganda which has been quite harmful to the development of the radium industry, the object being to make the production of radium a government monopoly, the argument in favor of this being that there is a total of not to exceed three and a half ounces of radium in the carnotite ore which can be mined in this country. Since this argument was first advanced (in 1914) most of the radium mentioned above has been produced, as it was only in January, 1913, that the first high purity radium was prepared in the United States, in the laboratories of the Standard Chemical Co. This company has since systematically developed its extensive carnotite holdings, and on the basis of findings the statement is fully justified that at least 20 ounces of radium can be prepared from Colorado carnotite. This flatly contradicts the estimates made by the employees of the Bureau of Mines and certainly weakens the arguments on governmental production of radium, or limitation of its use to therapy.

"The study of the phenomena of radio-activity, particularly the rays of the radio-elements and of the X-rays, has led to a clearer insight into the nature of the atom. According to Rutherford, the atom consists of a central positively charged nucleus surrounded by a ring or rings of negative electrons in rapid orbital motion. The nucleus is small in comparison with the dimension of the atom, and is made up of negative electrons with an excess of positive electrons. The positive electron is the hydrogen nucleus, which because of its smallness possesses a great electro-magnetic mass, 1700 times that of the negative electron. The hydrogen atom consists of a positive electron and one negative electron, which is in orbital motion about the nucleus. The helium nucleus consists of four hydrogen nuclei (positive electrons) and two negative electrons. The helium nucleus is remarkably stable, the experimental evidence indicating that the nucleus of the radio-element, when the atom transmutes, uses either a negative electron (beta ray) or a helium nucleus (alpha ray).

"In place of the old Periodic Law, we must now say that the chemical properties of the atoms are a periodic function of the nucleus charge. Isotopes are elements which have the same nucleus charge, but nuclei of different make up, consequently different atomic weights but identical chemical properties and spectra. Likewise two successive radio-elements which differ by a negative electron (mass electron = 1/1700 mass of hydrogen atom) will have sensibly the same atomic weights, but differ widely in chemical properties."



# Conversion of a Brewery Into an Oil Refinery

A Description of the Conversion of a Standard Type Brewery Into  
An Edible Oil Refinery, Utilizing the Equipment  
With Some Alterations and Additions

FOR more than fifty years the George Hauck & Sons brewery at Kingston has been brewing lager beer. It had a capacity of 35,000 barrels a year and was of the standard type of small brewery. For a number of years past the Messrs. Hauck of the present generation and Mr. J. B. Kearney have been considering the unfavorable prospects of small breweries, and early in 1917 they called into consultation Mr. H. E. Brown, a chemical engineer of 115 Broadway, New York, who lives in Kingston. He made a preliminary investigation and his first report offered three plans for the conversion of the establishment into another manufacturing enterprise. These were to engage in either of the following industries:

1. Oils, margarines and lard compounds,
2. The manufacture of maltose,
3. Dairy products, condensed milk, ice creams, etc.

They chose the first, and in June, 1917, Mr. Brown began intensive study of the subject, which continued for two months. Three specific oils were considered, viz., coconut, peanut and cottonseed, and of these peanut oil was recommended. The detailed report gave complete costs of converting the brewery into an oil refining plant. After checking up the report with care independently, it was adopted in its entirety and in September, 1917, the word was given to go ahead. The Hauck Food Products Corporation was organized to succeed the George Hauck & Sons Brewing Co. and in October, 1917, they stopped brewing. Under ordinary conditions they would have been able to begin refining last January, but owing to delays in the delivery of machinery caused by unusual war conditions they were not able to put through the first lot of oil until August, 1918.

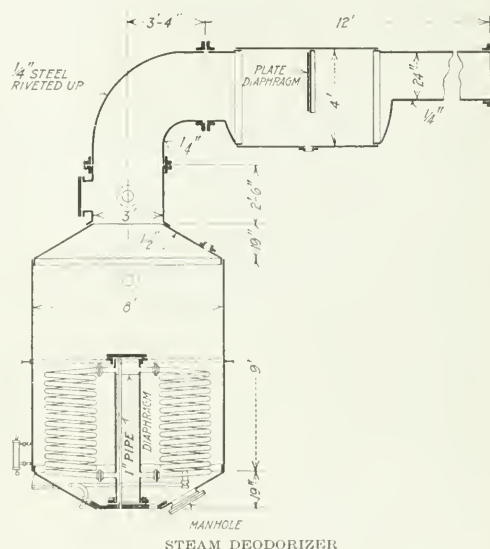
The time required for settling in the standard process of refining was a serious problem for their consultant, Mr. Brown. With the room and space available the capacity of the works would be limited, and after careful examination, tests and various consultations with the inventor, he resolved upon the process of refining invented and patented by Dr. Charles Baskerville, head of the department of chemistry of the College of the City of New York.

## RAPID SEPARATION OF FOOTS

The striking feature of the Baskerville process is that instead of allowing the foots to settle and then siphoning off the clear oil, the oil is agitated with wood pulp or cotton linters and caustic solution, and after adding an electrolyte to coagulate the albuminous substances upon the fibers and to harden the soap in the foots, the whole is driven through a filter press, whence the hot oil proceeds immediately to the bleaching apparatus and from there to the deodorizer. Additional details will appear in sequence; it is desired now merely to em-

phasize the need of sufficient speed in the operation to give the works abundant capacity and at the same time to manufacture a high quality product. With this in view Mr. Brown designed a special deodorizer, which is shown in detail and which operates very rapidly. The capacity of the works when certain minor conveniences are installed will be approximately 30 tons of refined, bleached and deodorized oil per day.

Drawings are shown of two cross-sections of the installation which are self-explanatory to those familiar



with both brewing and oil refining. It should be recalled, however, that the main features of a typical beer brewery are as follows:

1. The corn cooker,
2. The mash tun, or tub,
3. The brew kettle,
4. The hop jack,
5. The cooler,
6. Fermenting cellar,
7. Rest cellar (or Ruh cellar),
8. Storage cellars.

These have been transformed or replaced as follows: The corn cooker is replaced by a make-up tank for chemicals.

The mash tun becomes the refining kettle.

The brew kettle was sold and, being made of copper, it brought a good price. It was replaced by the deodorizer.

The hop jack was converted into a bleaching kettle. Fermenting and rest cellars are used for storage of crude and refined oils.

#### UTILIZATION OF STANDARD BREWERY EQUIPMENT

All tanks, except of course those which are porcelain lined, were made available for oil by putting on a special coating made up under amended specifications of a patent designed for other purposes. The combinations of vegetable and bituminous waxes with which brewery tanks are lined will not do for oils. It was necessary also to replace copper piping owing to the action of the metal upon free fatty acids. Steel piping was substituted. The pumps required changes in the packing.

The old mash tub was converted into a refining kettle by adding revolving paddles to the agitators, eliminating the double bottom and providing a coil of steam pipe on the sides for heating. This has a maximum capacity of about thirteen tons of oil. If the crude oil is high in its free fatty acid content, it is desirable to reduce the charge somewhat. First there was pumped into this vessel 17,200 lb. Oriental peanut oil containing 1.28 per cent free fatty acids. Steam was turned on at about 10 a. m. and the process continued under constant temperature control during the refining. Eighty pounds of dry cotton linters were added, the amount being determined by the free acids and albuminous matter present. Then 298 lb. of caustic soda of 24.1 deg. B. was added. Then, as the temperature rose and under constant stirring, 230 lb. of anhydrous salt cake was put in. This is the electrolyte which coagulates the colloidal substances and hardens the flocs upon the fibers of the linters while the clear oil holds them in suspension. The break is easily observed, and after it the agitation is slowed down for ten or fifteen minutes and then the whole is pumped under 60 lb. pressure through a Sweetland self-dumping filter press.

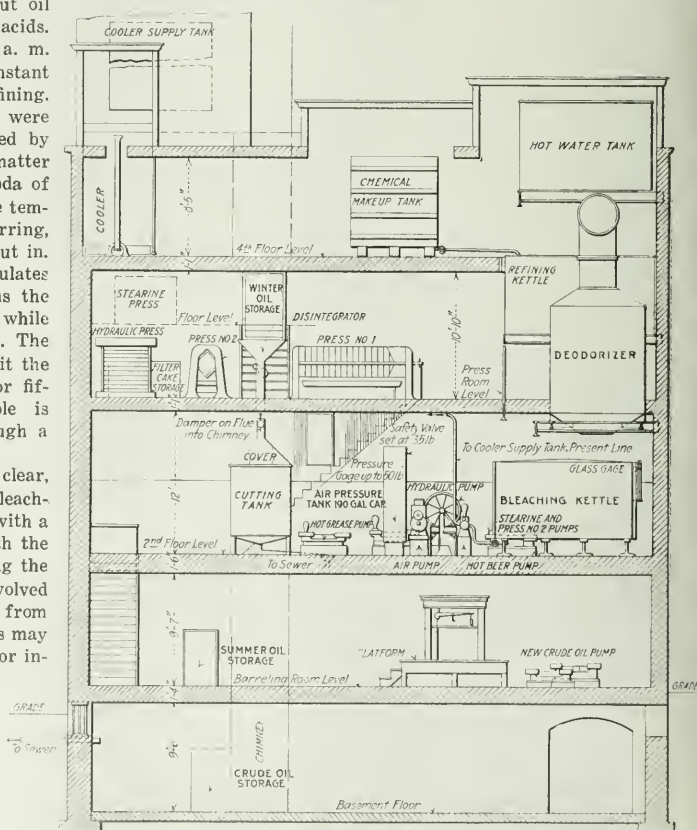
The oil runs through remarkably clear, and while still hot it is led into the bleaching kettle. This is the old hop jack with a stirring apparatus provided and with the requisite steam pipes for maintaining the temperature. No new principle is involved in the process, which carries the oil from simple brightening to water white, as may be desired. Fuller's earth, charcoal or infusorial earth may be employed, according to the results that are called for. When simple brightening is the object, infusorial earth is used. After bleaching the oil is run through a smaller Johnson filter press to remove the medium.

While still hot it is pumped to the deodorizer, the design of which is shown. It contains six coils of steam pipe (of which two are shown in the section), 24 inches in diameter. In the center of one of the coils is a propeller, the revolutions of which keep the oil in constant

circulation. A vacuum of 26 to 27½ inches is maintained above the oil and steam is let into the coils at first at boiler pressure. Then to increase the temperature superheated steam is introduced into the coils and at the same time superheated steam is let into a perforated pipe at the bottom of the apparatus. This passes through the oil, increases the agitation and carries off all the constituents which impart rancid odor and taste. The finish is determined by test samples. The oil is now at a pretty high temperature and would oxidize on contact with the air; therefore in the place of the superheated steam, cold water is introduced into the coils until the desired temperature is reached. The oil is then run into storage tanks and is ready for market.

#### THE SEPARATION OF THE FOOTS IN THE FILTER PRESS

The dehydrated causticized oil is filtered in a dumping Sweetland press, thereby separating the flocs from the refined oil. The cake is carried to a screw press, where 100 lb. per sq.in. force is applied to remove the oil content. The cake, which is now made up chiefly



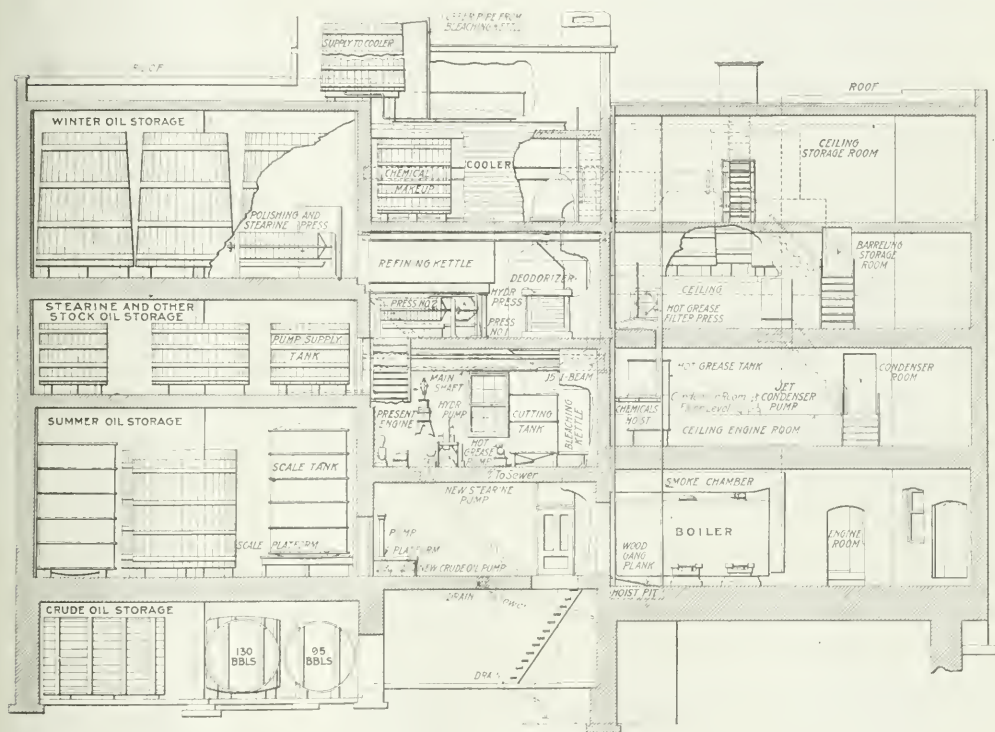
CROSS-SECTION OF REFINERY

of linters, soap and albuminous matter, is placed in a lead-lined kettle, where it is cut, and the free fatty acids liberated. The whole mass is then agitated and treated with hot water and steam and in this condition

sent to a wood-frame filter press operating on 30 to 40 lb. pressure and the linters separated from the free fatty acids, liquid albuminous matter and slight excess of oils, the cake being thoroughly steamed out, so that only traces of oil and free fatty acids remain with the linters. The mixture of water, free fatty acids and oils is then led to a separating tank, the water separated by gravity, thus leaving the foots in condition to be barrelled, ready for sale to the soap manufacturers. The amount of linters required in refining is so slight that this process is put through only occasionally. The pressed cake is stored until enough for a run is on hand.

the oil is, roughly, the amount of cotton linters needed in the Baskerville process, but this, as has been already noted, must be determined beforehand according to the content of free acid and albuminous matter.

Although it is easier to work with dilute caustic soda, this is not feasible with the Baskerville process because an excess of water tends to produce an emulsion with the soap formed, which is the very thing that must be avoided. The very lively agitation during the refining process and proper care in adding the caustic soda prevent irregularity in saponification and effectively neutralize the free acids. This point is important.



CROSS-SECTION OF REFINERY

This completes the process, but a few notes may be added. Anhydrous salt cake (or Glauber's salt) is used for the electrolyte in the refining process because it is economically available in Kingston. In another plant now in process of installation by Mr. Brown, sodium carbonate is used in place of it, and instead of cotton linters as the mechanical basis for coagulation wood pulp is employed and the foots are to be converted into soap powder. The pulp becomes gelatinized during the process.

Installation is under way to make winter oil in which the refined, bleached and deodorized product is to be piped to a cold storage room and refrigerated to zero deg. C. for a proper time to precipitate the stearines, after which the oils are filtered again, thus producing an oil which remains clear at zero deg. C. One-quarter to one-half of one per cent of the weight of

The company has had difficulty in getting satisfactory filter cloth owing to war conditions. It is necessary to clean the cloths carefully after each pressing inasmuch as the linters make a filter of themselves and unless the cloths are well laundered they clog up. It is planned to substitute Monell metal screens for this purpose.

In regard to margarine, for which among other purposes the oil is available, the laws provide a curious and needless expense. The normal color of good peanut oil is a beautiful yellow, slightly on the greenish shade, like olive oil. But if it is to go into margarine it must be bleached water white and the product, if it is to be yellow, must be colored by the final purchaser. It is a little point made by the farmers that a butter substitute must not look like butter when it is sold save against prohibitory tax. So the farmer colors his butter yellow and the housewife colors her margarine ditto



and we all know that there isn't butter enough to go around.

The plant is half a mile from the railway station and about an equal distance from the docks. To meet this situation a 5-ton tank truck has been provided which loads and delivers that quantity of crude oil in forty-five minutes.

The process requires constant chemical control. Rule of thumb methods will not do.

#### FIGURES ON REFINING LOSSES

In conclusion are given some weighings recorded in connection with the 17,200 lb. of oil which was refined in 32 minutes and filtered in 27 minutes:

|                                                   |                                                           |
|---------------------------------------------------|-----------------------------------------------------------|
| There was added to the oil in the refining kettle |                                                           |
| 80 lb. of linters                                 |                                                           |
| 298 lb. caustic soda. (24.1 deg. B.               |                                                           |
| 18.68 per cent NaOH)                              |                                                           |
| 230 lb. anhydrous salt cake                       |                                                           |
| or a total of                                     | 608 lb.                                                   |
| Wt. of re-pressed cake                            |                                                           |
| foots.....                                        | 909 lb.                                                   |
| Wt. of additions.....                             | 608 lb.                                                   |
| Refining loss.....                                | 301 lb. = $\frac{301 \times 100}{17,200} = 1.75$ per cent |
| Loss of oil = 1.75 — 1.28 = 0.47 per cent         |                                                           |

The foots after pressing weighed 411 lb. This is remarkable, indicating a refining loss of around 1.75 per cent when deduction is made for free acids, linters and the theoretical amount of soda. No weights were determined to check the weight of the brightened and deodorized oil, and it may be that the above figures involve some error.

### Products of the Electric Furnace and the Electrolytic Cell

One of the interesting exhibits at the recent Chemical Exposition was a chart in the booth of the American Electrochemical Society portraying the productions of the electric furnace and the electrolytic cell. This was compiled by Dr. C. G. Fink, past president of the Electrochemical Society. On account of the interest shown in the chart at the Exposition we reproduce it below for the benefit of those who were unable to attend.

| Raw Materials                             | Products                    | Applications                                                                                                                                                                                                                                                              |
|-------------------------------------------|-----------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Anthracite Coal.....                      | Graphite.....               | Electrodes, Lubricants and Paints.                                                                                                                                                                                                                                        |
| Sand, Sawdust and Coke.....               | Silicon Carbide.....        | Abrasives and Refractories.                                                                                                                                                                                                                                               |
| Bauxite (Natural Aluminium Oxide).....    | Artificial Emery.....       | Abrasives and Refractories.                                                                                                                                                                                                                                               |
| Bauxite.....                              | Aluminium Metal.....        | Cable, Aeroplane and Auto Alloys, Kitchen Utensils, Aluminothermic Reactions, Decidizing Steel, Camp Utensils, Ammonia (explosive), Speaking Tubes on Naval Vessels, Acid Containers.                                                                                     |
| Sand and Coke.....                        | Silicon.....                | Silicon—Steel, Hydrogen for Balloons, Resistance Units, Silicodes, Silicon Tetrachloride.                                                                                                                                                                                 |
| Quartz Rock.....                          | Fused Quartz.....           | Silica Tubes, Heat Resisting Materials.                                                                                                                                                                                                                                   |
| Coke and Sulphur.....                     | Carbon Bisulphide.....      | Solvent, Insecticide, Carbon Tetrachloride Viscos.                                                                                                                                                                                                                        |
| Phosphate Rock, Coke and Sand.....        | Phosphorus.....             | Matches, Phosphorus Compounds, Phosphor Bronze, Smoke Screens.                                                                                                                                                                                                            |
| Lime and Coke.....                        | Calcium Carbide.....        | Acetylene for Welding, Cutting and Lighting, Acetone, Acetic Acid, Aeroplane Dope.                                                                                                                                                                                        |
| Calcium Carbide, Nitrogen of the Air..... | Calcium Cyanamide.....      | Fertilizer, Ammonia, Cyanides.                                                                                                                                                                                                                                            |
| Iron Ore.....                             | Pig Iron.....               | Tin Plate Industry, Bronzes.                                                                                                                                                                                                                                              |
| Iron, Silica Rock, Coke.....              | Ferrosilicon.....           | Steel Industry.                                                                                                                                                                                                                                                           |
| Manganese Ore and Coke.....               | Ferromanganese.....         | Making Steel, Making Hydrogen.                                                                                                                                                                                                                                            |
| Chromite Ore.....                         | Ferrocrome.....             | Steel, Ferromagnates.                                                                                                                                                                                                                                                     |
| Tungsten Ore.....                         | Ferrotungsten.....          | Special and High Speed Steels, Armor Plate, Projectiles.                                                                                                                                                                                                                  |
| Molybdenum Ore.....                       | Ferromolybdenum.....        | Special Steels.                                                                                                                                                                                                                                                           |
| Titanium Ore.....                         | Ferrotitanium.....          | Scavenger in Steel Making.                                                                                                                                                                                                                                                |
| Zinc Ore.....                             | Pure Zinc Metal.....        | Brass Industry.                                                                                                                                                                                                                                                           |
| Water.....                                | Hydrogen and Oxygen.....    | Balloons, Oxywelding, Oxycutting.                                                                                                                                                                                                                                         |
| Water, Salt.....                          | Caustic (NaOH).....         | Soap, Paper Industry, Making Explosives.                                                                                                                                                                                                                                  |
| Water, Salt.....                          | Chlorine Gas.....           | Bleaching, Explosives, Chlor-benzol, Gas Warfare, Mustard Gas, Phosgene, Chlorpicrine, Silicon Tetrachloride, Water Purification, Smelting, Surgery (Dakin solution), Detonating, Artificial Plastics (Halowax), Hydrochloric Acid, Aluminium, Chloride for Oil Refining. |
| Water, Salt.....                          | Hypochlorite.....           | Disinfectants.                                                                                                                                                                                                                                                            |
| Water, Salt.....                          | Sodium Metal.....           | Peroxides, Cyanides, Bleaching, Mining.                                                                                                                                                                                                                                   |
| Water, Salt.....                          | Hydrogen.....               | Ballooning, Hydrogenate Fat (for cooking).                                                                                                                                                                                                                                |
| Magnesium Chloride or Magnesia.....       | Magnesium Metal.....        | Flashlight Powders, Light, Wright Alloys, Tracer Bullets and Flares.                                                                                                                                                                                                      |
| Air.....                                  | Nitric Acid.....            | Explosives, Fertilizers.                                                                                                                                                                                                                                                  |
| Air.....                                  | Ozone.....                  | Sterilization of Water.                                                                                                                                                                                                                                                   |
| Crude Copper.....                         | Pure Copper.....            | Electrical Industry.                                                                                                                                                                                                                                                      |
| Pig Iron.....                             | Pure or "Swedish Iron"..... | Tubes and Special Steels.                                                                                                                                                                                                                                                 |
| Potassium Chloride.....                   | Potassium Chlorate.....     | Primers, Matches, Dyeing.                                                                                                                                                                                                                                                 |
| Chromium.....                             | Sodium Bichromate.....      | Dyeing.                                                                                                                                                                                                                                                                   |

### Adhesive Waterproof Drawings and Tracings Without Crimping

BY JOHN S. CARPENTER

**W**ATERPROOFING of drawings and tracings so that they can be used in wet places is done by the use of a preparation composed of gum rubber and benzol.

Benzol dissolves rubber, and the compound thus formed will keep in any climate and under any conditions. As benzol is inflammable, it should be kept in a safe place in a covered jar. If the proper precautions are taken in its use, however, it is not dangerous.

In a quart jar put a piece of rubber about 4 in. square; to this add a half pint of benzol. The rubber will soon swell to three or four times its former bulk and will be ready for use in about 24 hours. To prepare for use take about half the above quantity and put it in another jar for thinning down. If drawings are to be coated use a rather thin solution that will spread well under a brush. The drawing should be coated on both sides. For use as an adhesive, the solution should be fairly stiff, so that if it is desirable afterward to separate the joined parts it can be done more readily than if thin paste is used. There are cases where large tracings and blueprints must be made up of smaller sections, and for this work the paste is invaluable, as the joints will not be crimped out of shape and alignment.

When some of this solution was spilled accidentally on a dirty drawing the benzol was mopped up with a rag and the rubber was rolled up into a ball. The drawing was cleaned very nicely during the operation. This suggested an additional use for the preparation.

Rubber bands instead of pure gum rubber were tried; but it was found that they would not dissolve, merely swelling to many times their former size. Formaldehyde was also tried as a solvent, but its objectionable odor and certain other characteristics have proved it to be undesirable. When diluted as above directed the pure gum paste will not be costly.—*Engineering News-Record*, Sept. 26.

## Nitrogen Fixation Furnaces—II\*

A Discussion of the Operating Technology of Arc Furnaces—Power Factor, Reactance, Air Supply, Increase of Pressure and Oxygen Concentration, Absorption of the Products and the Theory of the Reaction Between Oxygen and Nitrogen

By E. KILBURN SCOTT

THE expanding arcs of electric furnaces give a capacity or leading-current effect, and but for the large amount of reactance used to steady the furnace the power factor would be high. With diverging electrodes the arc at the commencement of each half period is small and gradually lengthens until it breaks, so the resistance may be represented by the rising line of Fig. 14. The low resistance causes the current at the beginning to be large, as indicated by the exaggerated current wave of Fig. 14. When compared with the voltage wave the effect is as if the current were leading, and in practice such is found to be the case. Diverging electrodes also act, with the air between, as a sort of condenser, and a feeble spark is sometimes noticed between the tips of the electrodes where they approach nearest together, which is due to the condenser action.

In the Birkeland-Eyde furnace the interaction of the magnetic field with the alternating current passing between the electrodes is also said to cause the current to lead. The power-factor is certainly higher than with the Schönherr furnace, and this may be due to the latter having a steel tube around the long arc, which gives an inductive effect such as would be the case if armor were placed around a single conductor carrying alternating current. Dr. C. P. Steinmetz considers that the "standing arc" of the Schönherr furnace acts in the opposite way to the expanding arcs of other furnaces, and the resistance of the arc being high at the start causes a current wave distortion which is equivalent to a lagging current.

### REACTANCES

Small choke coils or reactances can be made with adjustable iron cores; also the regulation of series arc lighting can be effected by an apparatus having movable coils. It would be useful to have such readily adjustable reactances for electric furnace working, but as the power required for furnaces is very considerable, it is difficult to keep a movable core or movable coils steady enough, and probably also the core would become too hot.

It is inconvenient to alter the amount of reactance by changing number of turns of a choke coil, because the one connected to the switch contacts would act for the time being as a short circuited secondary, and the large currents which would be induced are difficult to switch. One way to alter reactance while the furnace is running is to change the connections of the coils from series to parallel; another is to have a number of reactances in parallel and change the number of them in

circuit. This latter method is employed for the 4000-kw. Birkeland-Eyde furnaces. When starting such a furnace that has been relined, the method is to switch in only one of three reactors, which allows about 1400 kw. to pass. As the lining dries out the other reactors are switched in one after the other until the furnace receives the full 4000 kw.

During early experiments with a K. S. 3-phase furnace it was considered desirable to interpose transformers of one-to-one ratio between the furnace and the alternating current supply, so that in case any abnormal condition occurred a magnetic link between the two circuits would act as a protection to the alternator. By suitably adjusting the sectional area of the core and the disposition of the coils, the magnetic leakage varied with the current and regulation was very good. The writer understands that reactors on this principle are now used in Norway, the core being built on the lines of a Berry transformer, with groups of plates radiating from a central core around which are coils of circular shape. The magnetic forces are thus balanced, and the coils always retain their position.

Although many reactors are built with iron cores, there is a tendency to dispense with the iron because reactors without it are more accessible, and as the conductors are of bare copper supported in cement concrete they are fireproof. They have to be placed away from structural steelwork. One form of coil known as a "toroid" has the advantage of giving the greatest amount of self-induction with least amount of electrical resistance. It consists of bare copper strip wound concentrically into a flat coil with the turns spaced well apart and set in cement concrete.

A neat form of reactor made by the General Electric Co. is shown in Fig. 15. The conductor is bare copper wire, wound in slightly conical layers, the turns of the first layer progressing from outside to inside and of the second layer from the inside to outside, and so on. The layers converge where the voltage is a minimum, the clearance between turns being about an inch (2.5 cm.) for 6600 volts. The concrete is freed from metallic particles and cured in the presence of high pressure steam, and the whole is supported from the ground by porcelain post insulators.

### AIR SUPPLY

The yield of a furnace depends to some extent on the condition of the air blown through the arc, for if charged with dust particles, moisture or oil, or the acid vapors of large industrial centers, results are not so good as when the air is clean and dry. While working an experimental plant in Manchester, England, it was found that the yields on moist days were lower than

\*Completion of the paper read at the thirty-fourth general meeting of the American Electrochemical Society, held at Atlantic City, N. J., Sept. 30, 1918.

when the atmosphere was comparatively dry. The air should have an easy flow from the blower to the furnace, that is to say, pipes should be as short and straight as possible, and the branches of similar length, so that each furnace may receive the same pressure.

Expanding nozzles have been recommended for delivering air to the flame, but the writer has found them liable to set up throbbings in the air flow. To get even flow, the pressure at discharge has to be about half the initial pressure, and this condition is not easy to meet with air at low pressure and high velocity, because the expanding portion has to be excessively long. Air compressors of the reciprocating type are not suitable for the supply of air to nitrogen fixation furnaces, because the air must flow in an absolutely steady stream and be free from oil, etc., also such compressors are only ef-

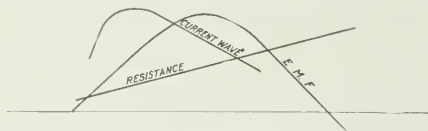


FIG. 14. SHOWING THE EFFECT OF ARCS WHICH INCREASE IN RESISTANCE

ficient for pressures above 15 lb. per sq.in. (1 atmosphere). Pressure blowers such as the Root type may be used, but as they also work by pocketing air and carrying it over to the delivery side, the pressure is somewhat uneven. They work efficiently with pressures up to about 8 lb. per sq.in. (0.5 atmosphere). Fans give steady flow, but are inefficient because they do not use the velocity energy of the air at the impeller exit. Also they are only efficient for pressures below 1 lb. or so per sq.in. (0.07 atmosphere).

Centrifugal compressors are a good type, because they are efficient and deliver a steady stream of air at pressures necessary for the furnaces. They resemble a centrifugal pump in having a rapidly rotating impeller surrounded by a stationary set of discharge vanes supported by the casing. For pressures up to 4 lb. per sq.in. (0.25 atmosphere) one impeller is used, and higher pressures are obtained by merely multiplying the number of impellers. The speeds are suitable for coupling them direct to either steam turbines or 60-cycle induction motors. With 25 cycles the motor speeds are lower and gearing has to be used.

#### POWER FOR CENTRIFUGAL COMPRESSOR

The amount of power required to blow the air through the furnaces depends on the pressure, but it is usually less than 3 per cent of the energy which is supplied to the furnaces. The theoretical horsepower required to compress adiabatically 100 cubic feet of air (3 cu.m.) at atmospheric pressure is given by the curve Fig. 16. It will be noted that it is not a straight line. Assuming that a 10,000-kw. factory requires 700,000 cubic feet (20,000 cu.m.) of air per hour, or 11,660 cu.ft. (330 cu.m.) per minute, then for a pressure of 5 lb. per sq.in. (0.33 atmosphere) the power is

$$\frac{11,660 \times 2}{100} = 232 \text{ theoretical horsepower.}$$

A centrifugal compressor for this duty would have two stages, and run at about 3450 rev. per minute with an efficiency of 70 per cent, so about 400 shaft horse-

power would be required. Allowing for efficiency of the motor, about 200 kw. would be supplied, and it will be seen that even at 5 lb. pressure the energy taken by the centrifugal blower is only about 2 per cent of the energy put into the furnaces.

The high speed of the centrifugal compressor makes it suitable for being driven by a steam turbine, and if the turbine is supplied with steam at 120 lb. per sq.in. (8 atmospheres) the consumption of steam may be assumed at about  $200 \times 18 = 3,600$  lb. (1,630 kg.) per hour.

#### PREHEATER

Preheating the air before it enters the furnace is advantageous because it raises the average temperature of the arc, and electrical operation is improved owing to the air being already in an ionized condition. With preheat the velocity of the air can also be lower than when the air is cold. For a given production of nitric acid the electric energy used is rather lower with highly preheated air.

The Schönherf furnace has a preheater combined with it, which takes the form of several annular tubes of steel around a central reaction chamber, and the entering cold air and the exit gases pass through these tubes in counter-current directions. As the gases leave the reaction chambers at over 1000 deg. C. it is possible to give a very high preheat to the entering air. At Saaheim, in Norway, there are 96 of these furnaces of 1000 kw., each one with its own preheater. The Birkeland-Eyde furnace has also a preheater, because the air passes into the reaction chamber through a large num-

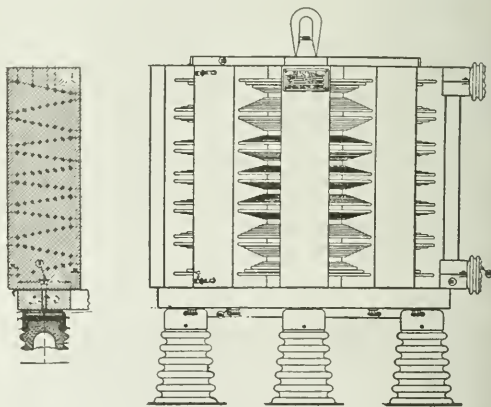


FIG. 15. REACTOR MADE BY THE GENERAL CHEMICAL COMPANY

ber of small holes in the refractory chamotte lining. As the electric arc keeps this lining at red heat, the entering air is preheated somewhat before it strikes the arc. This lining constitutes one of the objections to this furnace, because it is expensive to build and takes several days to dry out.

In several ways it is an advantage to employ a separate preheater, to serve a number of furnaces, one reason being that it can be designed efficiently to give the heat exchange. Also, hot air is always available in starting a new furnace, for when a furnace has its own preheater some time must obviously elapse before heat is available to warm up the incoming air.



It is usual to employ boilers to utilize the bulk of the heat from the furnace gases in raising steam. If the gases leave the boiler at 250 deg. C. and a further 150 deg. C. is absorbed in the preheater, then the preheater may be made of steel. At the same time it is advisable to have it in several units so as to take care of the expansion due to difference in temperature at the two ends. Thin steel tubes may be used, and the air should pass around them.

#### EFFECT OF ADDING OXYGEN

By weight air consists of 23 per cent oxygen and 77 per cent nitrogen; or by volume 20.7 per cent oxygen and 79.3 per cent nitrogen. One pound at 62 deg. F. and barometer at 30 inches occupies 13 cu.ft. (1 kg. = 0.81 cu.m.). One pound of oxygen at 62 deg. F. occupies 12 cu.ft. (1 kg. = 0.75 cu.m.), and is contained in 56 cu.ft. of air (3.5 cu.m.).

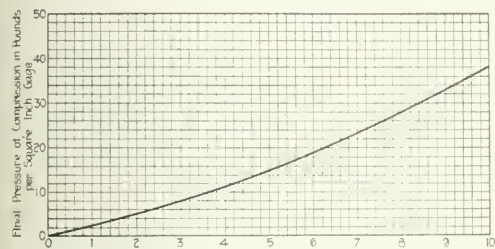


FIG. 16. CURVE GIVING THEORETICAL HORSEPOWER TO COMPRESS AIR

It is an advantage to add oxygen to the air passing through the furnace, because the concentration of nitric oxide is a maximum when the product of oxygen and nitrogen is also a maximum. It can be shown that it is directly proportional to the square root of the product; thus the equation for air is:  $0.21 \times 0.79 = 0.16$ . And for equal parts of oxygen and nitrogen  $0.5 \times 0.5 = 0.25$ . The increased yield is therefore 20 per cent, as shown by the ratio:

$$\sqrt{16} : \sqrt{25} :: 100 : 120$$

Commercially it is only possible to add oxygen when the process is worked in a closed cycle, the amount required continuously being then only that which the nitric oxide takes up.

If we assume that a factory utilizing 10,000 kw. requires 700,000 cu.ft. of air (20,000 cu.m.) per hour then 21 per cent of this, equal to 145,000 cu.ft. (4140 cu.m.), represents the oxygen. After passing through the furnace the air contained about 1.5 per cent nitric oxide of which about half is oxygen. The oxygen does not have to be pure, and if the oxygen-producing apparatus makes a mixture of 75 per cent oxygen and 25 per cent nitrogen, then about 1 per cent of the 145,000 cu.ft. (4,140 cu.m.), or, say, 1450 cu.ft. (41.4 cu.m.), per hour will have to be added continuously.

Addition of oxygen (to the air) is equivalent to increasing its pressure, for in air it occupies only one-fifth of the volume, whereas when it is equal with the nitrogen it occupies half of the volume. The effect is, therefore, the same as increasing pressure  $2\frac{1}{2}$  times, be-

cause much more oxygen is passed through the furnace. This is equivalent to  $14.7 \times 2.5 = 35$  lb. per sq.in. (2.4 atmospheres), yet at the same time the furnace walls do not have to withstand any extra pressure.

Pure oxygen and hydrogen can be made by electrolysis, but it requires a great deal of direct current. Also pure oxygen and nitrogen can be made from liquid air, but this requires much machinery and power. In some cases, however, oxygen made by these methods is a by-product of other manufacturing processes. Thus oxygen is a by-product of plants making hydrogen for fat hardening; also it is a by-product in the manufacture of calcium cyanamide, because that process only requires pure nitrogen. Where it can be obtained such by-product oxygen should be cheap.

Hitherto the manufacture of oxygen has been practically a monopoly and in consequence prices have been kept at a high level and little improvement made in methods of manufacture. In the near future there is every possibility of oxygen being produced in larger quantity and much cheaper. The Jefferies-Norton process for air separation makes use of liquefaction and distillation, but it has new features in the method of heat exchange and in the still. In general appearance the apparatus is very similar to the Claude system, but an essential difference is that the major part of the nitrogen is not expanded but issues at its original pressure. The nitrogen is heated and then expanded in a gas engine to furnish power to drive the plant; thus no outside power is required, as the heat applied to the nitrogen develops all that is necessary to drive the compressors.

It is possible also that the centrifugal method of separating the gases of air may be made a commercial success. This acts on the difference in weight of oxygen and nitrogen. It should be noted that a mixture of oxygen and nitrogen will do so long as the oxygen is in excess.

#### EFFECT OF INCREASING PRESSURE

It is known that increased yields can be obtained by increasing pressure in the reaction chambers of arc furnaces, but hitherto the pressures used have been sufficient only to move the air quickly through the arc. Extra pressure means more power to drive the centrifugal compressor, and the question is whether a larger plant requiring more power to work it would be justified by the increased yields obtained. Concentration is about doubled at 100 lb. pressure.

In any case there is no need to use such "heroic" high pressures as 1500 to 2000 lb. per sq.in. (100 to 135 atmospheres) which are necessary for the Haber process of making synthetic ammonia. Such pressures can be dealt with on a laboratory scale, with small tubes and apparatus, but they are troublesome on a large scale. It is difficult to retain hydrogen and to prevent it forming an explosive mixture with oxygen, also it occludes into the steel casing and makes it brittle.

Air at high pressure has a greater insulating value than air at low pressure, as shown by the fact that sparking between the metal quadrants of an electrostatic voltmeter may be stopped by merely increasing the air pressure. Owing to lower pressure at high altitudes the corona effect on transmission lines is also more pronounced.

It should be noted that a small pressure is caused by the explosions from the arcs in the furnace. When a furnace is first started up these are very pronounced and of varying intensities, but after the furnace is heated the explosions become less intense and more numerous.

#### ABSORPTION

Fig. 17 is a diagram indicating the approximate temperature of the gases as they pass through the system, when it is desired to make nitric acid. Boilers reduce the temperature from about 1000 deg. C. to 250 deg. C., and a heat exchanger then reduces the gases to about

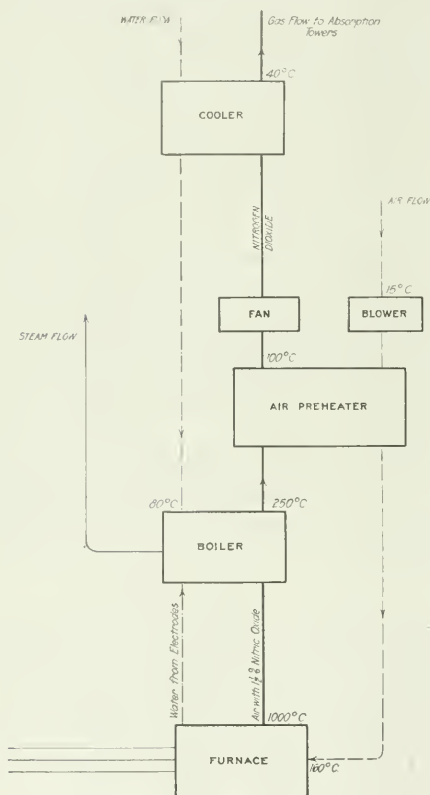


FIG. 17. SHOWING FLOW OF GAS AND AIR AND APPROPRIATE TEMPERATURE

100 deg. Finally a water cooler brings them down to 40 deg. C. or lower. The final temperature obviously depending on the temperature of the cooling water, it would probably be possible in winter to reduce the temperature to about 20 deg. C. The lower the temperature of the gases in the absorption towers, the better is the absorption, and that is the reason why stronger acid is obtained in winter than in summer.

As the gases leave the furnace they are at high temperature and must be carried in ducts lined with firebrick. Between 250 deg. C. and 100 deg. C. steel may be used, but below 100 deg. C it is well to use aluminium or acid-proof stoneware, as silicon-iron cannot be used. The water cooler should also have aluminium pipes, as acid may form. Before the gas enters the towers it is

necessary to facilitate the oxidation of all the nitric oxide to nitrogen dioxide, and for this purpose large open spaces are necessary through which the gases can flow sluggishly.

It is of some assistance to have connecting pipes of large cross-section. At Rjukan II, Norway, the furnaces are about 3000 feet (0.9 kilometer) from the absorption towers and the gases are carried through an aluminium pipe about 3 ft. (0.9 m.) diameter. The gases enter the pipe at about 200 deg. C., and are cooled down considerably while passing through it.

With gases at 40 deg. C. and 1.5 per cent nitric oxide concentration, the nitric acid can be easily made to about 33 per cent, which is correct strength for the manufacture of ammonium nitrate and calcium nitrate.

When sodium nitrite is required, the gases must enter the absorption towers at about 250 deg. C., because at this temperature only about half the nitric oxide has been changed to nitrogen dioxide and this mixture when absorbed by sodium carbonate or caustic soda gives sodium nitrite without any nitrate. For this product the absorption towers can be much smaller than those for making nitric acid, and they are also cheaper because they can be made of steel plate instead of acid-proof brickwork. Considerable quantities of sodium nitrite are required for the aniline dye industry, and it is also used for drugs and the pickling of meat, etc.

#### COOLING THE GAS

The chemical reaction of nitrogen and oxygen is reversible, but the tendency for nitric oxide gas to dissociate is only slight at below 1500 deg. C. The problem is therefore to jerk the nitric oxide from arc temperature to below 1500 deg. C. To a certain extent this is performed automatically by the air which surrounds the arc streamers, and it is probably most effective just at the moment when the arc breaks. Passing the air at high velocity through the flame is also advantageous, and at the same time the fixed gas and air should be withdrawn from the top of the furnace by an exhaust fan.

Several ways have been employed for expediting the cooling; for example, in the Pauling type of furnace some of the cooled gases are re-introduced again at a point just above the zone of maximum temperature. Another method is to impinge the top of the arc flame into a cooler, which may take the form of a steam boiler. During experiments with an early model of the K. S. 3-phase furnace, a boiler was set low enough for the electric arc flames to play against the tubes, when it was noted that they flickered about the surface much the same as do the flames of ordinary coal gas, and the boiler was not detrimentally affected. This plan takes advantage of the latent heat of steam, and the cooling is just as good in a large furnace as a small one. The boiler or cooler is connected to earth, but as the center of the flame is the neutral point of the 3-phase system no current passes, as the phases are in balance. As a matter of fact, the bulk of the electrical energy delivered to a furnace passes between the electrodes near the bottom of the flame.

#### STEAM FROM BOILERS

The most economical way to cool furnace gases is to pass them through boilers and to employ the steam so produced for various purposes in the factory, such as

evaporating water for the end products, etc.; also, as indicated below, the steam may be used to generate electric energy and so work regeneratively.

In order to show how much steam can be raised by the heat of furnace gases it may be of interest to give some figures for a plant equipped with furnaces to utilize 10,000 kw. and supplied with about 700,000 cu.ft. of air (20,100 cu.m.) per hour. At atmospheric pressure the volume of air containing 1.5 per cent of nitric oxide gas would be about 12.5 cu.ft. per lb., and therefore 700,000 cu.ft. (20,100 cu.m.) will weigh

$$\frac{700,000}{12.5} = 56,000 \text{ lb. (25,500 kg.)}$$

Assuming that the air and the nitric oxide enter the boiler at about 1000 deg. C. (1800 deg. F.) and leave at 250 deg. C. (450 deg. F.), then the difference of temperature is 750 deg. C. (1350 deg. F.) The specific heat of air is about 0.24, so the total heat in B.t.u. will be  $1,350 \times 0.24 \times 56,000 = 18,000,000$  (4,500,000 cal.) Assuming that about 970 B.t.u. are required to evaporate a pound of water into a pound of steam at atmospheric pressure, the steam will amount to

$$\frac{18,000,000}{970} = 18,500 \text{ lb. per hr. (8400 kg.)}$$

Allowing for loss by radiation through the brick-work setting and the steam drum, the total steam may be assumed at 18,000 lb. (8200 kg.) per hour.

Steam at 125 lb. per sq.in. (8.5 atmospheres) is suitable for evaporating purposes, and if the steam has to be carried some distance it is well to add about 50 deg. F. of superheat, making a total temperature of about

$$350 + 50 = 400 \text{ deg. F. (200 deg. C.)}$$

In a very large installation, more steam may be generated than is required for evaporation of end products, and in that case it can be used for generating electric energy. In the latest installation at Rjukan II, in Norway, there are three 4000-kw. steam turbine alternators supplied with steam by the hot furnace gases. It is very significant that in an installation having practically unlimited water power, steam turbines should have been installed, and indicates the saving there would be by combining an air nitrate factory with a power house equipped with steam turbines.

If all the steam from a 10,000-kw. plant was to be used in turbo generators having a steam consumption of say 18 lb. (8.2 kg.) per kw.-hour, then the energy would be

$$\frac{18,000}{18} = 1000 \text{ kw.}$$

That is to say, about 10 per cent of the energy put into the furnaces can be regenerated.

The boilers may be of any pattern so long as they are gas-tight, and they may form part of the furnace, or be separate, as in Norwegian installations. The feed water should be hot, so that moisture may not be deposited on the tubes, and for this purpose the water used for cooling electrodes and gases is employed and there is a further saving of heat.

In many discussions on the subject of nitrogen fixation in arc furnaces it has been assumed that the sole factor bringing about formation of nitric oxide is a thermal one. This is very doubtful, however, because all data relating to the laws of thermo-dynamic equilib-

rium have been obtained at temperatures very much lower than those commonly met with in electric furnaces; therefore it does not follow that the same laws hold good for arc temperature.

Dr. Maxted states, in the proceedings of the Society of Chemical Industry for April 15, 1918, that:

"Purely thermic interpretation of the nitrogen oxide reaction depends on a large extrapolation from lower to higher temperatures, and assumes that no latent factors cause increase or decrease in the observed temperature coefficients."

Some experiments by Mr. J. L. R. Hayden (see Trans. A. I. E. E., 34, 613) lead him to the conclusion that in fixing nitrogen by the electric arc the conditions of thermo-dynamic equilibrium are of secondary, if of any, moment. In other words, the process is essentially an electric one. His experiments were made with electrodes of various material which gave different temperatures, and the order of their nitric acid production was as follows:

| Concentration | Boiling Point<br>(Arc Temperature) |
|---------------|------------------------------------|
| Iron—Highest  | 2450 deg. C.                       |
| Titanium      | 2700 deg. C.                       |
| Carbon        | 3600 deg. C.                       |
| Copper—Lowest | 2310 deg. C.                       |

It will be seen that although carbon gives the highest arc temperature it is relatively inefficient in producing nitric oxide. Also the iron and copper, which give approximately the same arc temperature, are at opposite ends of the scale in producing oxide.

Another experiment made with the mercury arc, which has a much lower temperature than the above, showed that it was easily possible to get concentrations above those representing thermo-dynamic equilibrium. In electric furnaces there are other phenomena besides that of heat, for example, ionization, which appears to have the effect of disrupting the nitrogen molecules and so facilitating their combination with surrounding oxygen. It is conceivable also that the electric stress due to the high voltage and the magnetic field set up by the currents may have some effect.

Mr. Cramp, of Manchester, found that there was an increase of nitric oxide when ozone was added to the air passing into the arc flame, and it may be that  $O_3$  and the corresponding polymer of nitrogen, which Sir J. J. Thompson calls  $N_p$ , are formed momentarily, and then, dissociating, the nascent atoms of oxygen and nitrogen combine.

### Platinum Released

Under an order of Nov. 14 from the Bureau of Mines, licenses will no longer be required in connection with the handling of fireworks or the precious metals platinum, iridium and palladium. Many of the numerous chemicals entering into the manufacture of explosives are used constantly for other purposes, and under the new order no restrictions will obtain on the handling of these chemicals when not used in the manufacture of explosives. Licenses are still required for the handling or all such ingredients when intended to be used in explosives manufacture, however.

The explosives regulation was passed by Congress in October, 1917, with the aim of putting a stop to the numerous incendiary explosions and fires occurring at war munitions and other industrial plants.



## Helical and Elliptical Springs\*

A Discussion of the Manufacture of Elliptical and Coil Springs—Types of Steel Alloys Used—Methods of Testing—Formulae of Calculating Loads, Deflections and Torsion—Effect of Overstrain—Molecular Hysteresis

By CHAUNCEY T. EDGERTON

A SPRING may be defined as a device for the storage or re-distribution of mechanical energy. That may not be a very scientific definition, but it will at least serve to point the distinction between the two general classes of springs; first, those subjected to transverse stress, and, second, those subjected to torsional stress. Springs coming under class 1 are usually made of flat steel, in which one dimension of the section is much greater than the other. The common example of this class is the usual railroad "leaf" or "elliptic" suspension spring, and a similar type is, as you know, the standard spring for automobile suspension.

This paper will be largely confined to these types, from lack of time to speak of the many interesting kinds of special springs—of volutes, very popular as railroad suspension and buffer springs in Europe and which give such splendid results when properly made; of safety valve springs, which are often ordered to a tolerance of  $\frac{1}{16}$  in. on the loaded height, and so carefully made are the springs and so accurate is our working theory that they can be figured almost to a dot; of indicator springs, on which the requirements are so severe that the manufacturers think they are doing well if they get one spring right in ten.

### MANUFACTURE OF ELLIPTIC SPRINGS

I will run briefly through the series of operations involved in the manufacture of elliptic springs before taking up a few interesting points connected with the design. The plates are sheared to length cold in a slider-head shear, and then are either punched or nibbed at their center. (Automobile spring plates are usually bunched and assembled with a bolt or rivet. Railroad spring plates have a little conical nib pressed up in the center; the nibs of adjacent plates nest into each other and lock the plates together.) Next the main plate of the spring has an eye rolled up on each end, or else it has a drop-forged pad welded to each end, or some other means is provided for engagement with the hangers. Usually two or three plates besides the main plate are cut the full length of the spring; the remainder of the plates are regularly shortened, or "stepped." These are usually tapered down at each end in tapering rolls, and trimmed off square, half round or pointed. The plates are then ready to be fitted.

From time immemorial, elliptic springs have been fitted by hand. Even now the great majority of railroad springs are so fitted, while with automobile springs, the proportion of those machine fitted is somewhat

greater. Spring fitting is more nearly a skilled labor proposition than any other major operation in a spring mill, and a good fitter is a fairly well-paid mechanic.

Elliptic springs of alloy steel are hardened and drawn in pyrometer-regulated furnaces and baths, but carbon steel springs (that is, the vast majority of railroad elliptics) are hardened and tempered in a single operation, each plate going into the tempering oil as soon as it is fitted, without being re-heated. The hardening medium used is rather mild—either common black mineral oil or something like "Haughton's Soluble," and it should be hot—about 300 to 350 deg. F. The "drawing" operation varies in different shops. Many good fitters "flash" the plates; that is, they withdraw each plate from the oil after an immersion of about half a minute, so that it still retains heat enough to ignite the oil which adheres to it. Of course the flashing itself does nothing to the steel; it is simply an indication that the plate retains heat enough to draw itself down to a spring temper. Other fitters leave the plates in the oil until cold, and then draw them in a low-temperature furnace to the proper color. The plates are then ready to be banded or bolted together, and the spring tested.

It is surprising to find what excellent and uniform results a good fitter will obtain with this seemingly primitive method of heat treatment. When I was conducting experimental work in the shops, I used to go around occasionally after the fitters had gone home, and steal half a dozen tempered plates at random from their tables. The next day I would give these a transverse load test; and while they would not average up quite so well as heat-treated plates, I would find occasional specimens which on static test would equal the best results I could obtain from the most careful heat treatment. There is, of course, no good reason why this should not be so. The one great advantage obtained from careful heat treatment is uniformity. If the average excellence of the various plates in an elliptic spring determined the life of the spring, the advantages of special heat treatment over the handiwork of a first-class spring fitter would be but slight. The trouble is that an elliptic spring is only as strong as its weakest plate.

I also used to test these flat plates to destruction under repeated loads, alternating from zero to a fixed maximum stress. In these tests the difference between hand-tempered and specially treated plates was more marked than in the static tests. Pyrometer treatment would usually give a fairly uniform life before failure, while the life of hand-tempered plates was decidedly erratic.

All springs made from alloy steels are given special pyrometer heat treatment. After the plates are fitted they are allowed to cool, and are then reheated in a

\*Read before the Pittsburgh Section, American Electrochemical Society, May 10, 1918.

special furnace, preferably of the muffle or semi-muffle type. They remain in the quenching oil till cold, and are then drawn to spring temper in a lead or salt bath or a low-temperature furnace also regulated by pyrometer. In some automobile spring shops I understand they provide a bank of three furnaces for each fitter—one for heating to fit, one for heating to quench and the third for drawing. Personally I prefer to make the heat treatment an independent operation. I had excellent success with a treating furnace built as shown in Fig. 1. These furnaces heated uniformly and quite rapidly—much more so than a muffle fire. It is important to have the heating chamber amply large. If it is too small or if the arch is too low, the heat will be "spotty" and it will be very difficult to bring a charge of any size up to heat without losing control of the temperature.

Speaking from a commercial standpoint, the problem of high temperature regulation and measurement is not so much a question of knowing what temperature you have in your furnace as of insuring that the work, or charge, is at furnace temperature. This is particularly true with material like elliptic spring plates, which have to be handled very gingerly when they are hot, so as not to change their camber and destroy the "fit." It is necessary to put a number of these plates into the furnace at a time in order to secure reasonable economy

took considerable time and cost some money, but the results were worth it.

For the drawing operation there is nothing like a lead or salt bath. A furnace is difficult to regulate at the low temperatures desired, owing to the small body of contained heat in the furnace; whereas a lead bath such as we use in a spring shop contains two or three tons of lead, making a heat reservoir capable of very accurate control and yet capable of being brought up to temperature in a reasonable time.

#### COMPOSITION OF SPRING STEEL PLATES

The standard analysis of carbon spring steel is:

Carbon .....0.90 to 1.10 per cent

Manganese .....Less than 0.50 per cent

Phosphorus and sulphur. Less than 0.05 per cent

For carriage and wagon spring work the carbon is often lower, so that the plates can be dipped in water. For railroad elliptics most mill men prefer carbon not over 1 per cent. You are all doubtless familiar with the long-standing prejudice in favor of low phosphorus and sulphur. I am more afraid of high manganese in spring steel than of high phosphorus. I believe some authorities claim that it takes about 0.25 to 0.30 per cent of manganese to thoroughly de-oxidize the melt, that this is the sole function of the manganese content and that any higher manganese serves no good purpose. I have always obtained best results from steels running 0.30 to 0.40 per cent manganese; toward 0.50 per cent I begin to look for trouble.

Of the alloy steels the favorites for high grade elliptics are chromium-vanadium, chromium-nickel and silico-manganese. These are used mostly in automobile work, although a few railroads use chromium-vanadium steel for some or all of their elliptic springs. The Ford people claim that after exhaustive experiments they have demonstrated chromium-vanadium to be the very best for springs, and they use nothing else. Several other leading automobile concerns use the same types; perhaps a larger number use silico-manganese. There are several varieties of chromium-nickel spring steel, but not much is used, and I know very little about it from personal experience.

Chromium-vanadium spring steel, as originally proposed by the American Vanadium Co., analyzed 0.40 to 0.50 per cent carbon, about 1.25 per cent chromium, about 1.00 per cent manganese and 0.20 per cent vanadium. This made a very tender material, of most remarkable physical qualities if treated properly, but it is a little difficult to get the right treatment. One of the big producers has kept pretty close to this original analysis, simply reducing the chromium to an average content of about 1.10 per cent. Other steel makers, after lots of trouble with spring makers who couldn't or wouldn't heat-treat properly, now make chromium-vanadium steel containing about

0.43 to 0.52 per cent Carbon

0.80 to 1.10 per cent Chromium

0.60 to 0.80 per cent Manganese

still it is quite tender. That and its cost are the two objections to its use in springs. If properly treated and cost is no object, it is a wonderful steel.

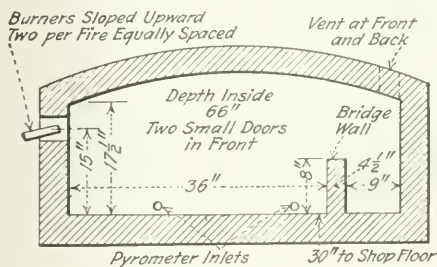


FIG. 1. CROSS-SECTION OF HEAT-TREATING FURNACE, LOOKING TOWARD REAR.

of operation; and as it is impracticable to have more than one or two pyrometer fire ends in each fire if you are operating a bank of fires, success depends much on the experience, skill and judgment of your pyrometer man.

As far as the actual reliability of the pyrometers is concerned, good results may be obtained in any one of several ways, but they all involve much care and constant checking. I still believe that the way I adopted when handling this work was the best. After several heart-rending experiences I bought a first-class high resistance millivoltmeter, had my own couples made up by a handy little German machinist in our own shops and calibrated them from a "standard" couple, thoroughly seasoned by long exposure to high temperatures and calibrated direct from three or four freezing-points. The points used were those of eutectoid steel, common salt, sodium sulphate and barium chloride. These gave a range covering the quenching temperature of any kind of spring steel; they were materials easily obtained and with well-defined freezing points. This practice



Silico-manganese spring steel, as usually made in this country, is modeled after the French Le Moyne and the Austrian Poldhi steels. The analysis is:

|                |                       |
|----------------|-----------------------|
| Carbon.....    | 0.50 to 0.60 per cent |
| Manganese..... | About 0.80 per cent   |
| Silicon.....   | 1.80 to 2.00 per cent |

This is not so tender a steel as chromium-vanadium. Some metallurgists are skeptical about the anti-fatigue qualities of silico-manganese steel, but it is in high favor as an automobile spring steel, and with the most ordinary care in heat treatment will make a very good record.

#### TESTING ELLIPTICAL SPRINGS

Before passing on to helical springs, just a word or two about the testing of elliptical springs. The usual design-stress for railroad elliptics is 70,000 lb. per sq.in., under the carbody or engine load; and it is customary to give the springs a static test before shipment of 50 to 100 per cent over the working load. Autographic tests on springs in service indicate that on an average roadbed a well-designed spring will suffer a maximum deflection under shock and vibration of not more than 50 per cent in excess of the static deflection under carbody load. Frequently, however, the vibration due to inequalities of roadbed cause an absolute deflection in the springs of  $\frac{1}{2}$  in., 1 in., 2 in. or some other figure which bears no particular relation to the deflection under carbody load; or, in other words, this absolute deflection would be about the same if the design of the spring were changed so as to make it more flexible or less flexible. But if the spring is made more flexible, any absolute deflection of  $\frac{1}{2}$  in., 1 in., 2 in. or whatever the maximum may be will be a smaller percentage of the deflection under rated load; and conversely the percentage will be greater in a less flexible spring. But with the rated load at a fixed fiber stress, this is tantamount to saying that a flexible spring will be subjected to smaller maximum stresses than a stiff spring; consequently the life of the flexible spring will be longer. This all seems self-evident; and yet you would be surprised to find how impervious many spring users are to this simple argument. They will look at nothing but the design-stress for the carbody load; if that is all right, then the spring is all right.

The condition I have just described is greatly exaggerated in automobile service, where the road conditions are far more severe than in railroad work. An automobile spring should be designed so that it will stand an indefinite number of deflections to the point where it will hit the frame or the rubber bumpers.

I have already spoken of the transverse tests I made when engaged in investigation work. I made hundreds of these, both static and fatigue tests, under all sorts of conditions. Needless to say, I obtained some very interesting results, but only have time now to refer to one or two of these.

When the chromium-vanadium spring-steel people began to visit us and talk their product, their favorite piece of propaganda was to take a piece of their steel eight or ten inches long, heat-treat it very carefully and then break it transversely. They would then show us the peculiar long "scarf" formed by the break, the fibrous,

hickory-like appearance of the fracture, ask us to compare this with the square break and crystalline structure of carbon steel in a similar test, and invite our reverent admiration for their wonderful steel. This was duly forthcoming until I began to make some fatigue tests on this same steel. Then I found that these plates, tested under repeated loads which were well within the elastic limit, broke with a clean, square fracture, showing no trace of that wonderful "hickory" fiber. What became of this fiber? I have never found a conclusive answer to the question. My own guess is that the fiber is a condition set up by the rolling, which gradually disappears as the metal becomes fatigued.

These fatigue tests would distinguish between "mild" and "tender" steels very consistently. Chromium-vanadium steel would often make an excellent showing in static tests over a considerable range of treating temperatures, but when the same heat of steel was put through fatigue tests the treatment had to be right within a very narrow margin to get anything like maximum results. On the other hand, carbon and silico-manganese spring steels would show long life over a comparatively wide range of analysis and heat treatment.

#### CALCULATION OF ELLIPTIC SPRINGS

The formulæ for the calculation of elliptic springs, as laid down in the text books, are tolerably correct. The load formula is:

$$P = \frac{2 S b h^2 n}{3 L}$$

where P is the load at the center of the springs, S is the corresponding fiber stress, b and h are the width and thickness respectively of the plate section, n is the number of plates, and L is the effective length, with the width of band deducted. The deflection formula for a semi-elliptic spring is:

$$\text{Deflection} = \frac{3 P L^3}{48 E h^3 n}$$

E being the elastic modulus of the material. For a full elliptic the deflection will, of course, be twice as great. The deflection formula is approximately correct only when the plates are spaced according to theory. Most mill men use empirical deflection formulæ, and on a lot of any size they set up a trial spring before fitting the lot, as the deflection is subject to several disturbing practical conditions which make it difficult to figure accurately.

#### MANUFACTURE OF COIL SPRINGS

We come now to the second grand division of springs—those which are subjected to torsional or twisting stress. The majority of these are helical springs, or, as they are generally known in the trade, coils. They are further classified into extension or compression springs, according to the nature of the loading applied; this classification has nothing to do with the nature of the stress produced in the material. They are also divided from a manufacturing standpoint into hot-wound and cold-wound springs; if the material is larger than  $\frac{3}{8}$  in. round or square they are usually wound hot, while the smaller sizes are wound cold. The material



used may be either round, square or rectangular in section, and our English cousins rather favor certain sections of irregular shape. Railroad bearing springs as used in this country are practically all round-section compression springs, hot wound.

The manufacture of these springs is quite simple. The bars are cut to the proper length, and each end tapered down in a big tapering roll, each of these tapered ends having a length of about three-quarters of a turn of the finished springs. The bars are then wound or coiled on a cylindrical mandrel with just enough taper to permit of sliding the spring off without distorting it. The pitch is regulated by feeding the bars into the machine in direct contact with a revolving grooved worm; where very accurate pitch is required, the bars are fed in through a worm-driven feed carriage, similar to the leadscrew and tool-carriage of a lathe. The springs are then dressed, so that the tapered ends lie flat and square, and are then quenched in the tempering oil. In ordinary commercial work it is not necessary to flash or draw the springs, as the oil gets pretty hot, and the size of the steel is usually such that it does not cool fast enough in the oil to get very hard. The springs are then tested solid, or coil to coil, two or three times, also tested for load if any is specified.

Small lots of wire springs are wound on a lathe in lengths up to the capacity of the machine. They are then cut to length, the ends heated over a little slot furnace and dressed in by hand, and ground to a bearing on an emery wheel. Large lots are coiled in automatics, in which feed-rolls drive the wire onto a stub mandrel, around which it is bent by rollers. The dressing of the ends is done automatically, the "pitch plug" dropping back every so many coils and allowing one coil to be wound close. Some automatics also cut the springs off. On small sizes these machines will turn out two or three thousand springs an hour, coiled, dressed and cut, ready for grinding. It takes some time to set up one of these automatics for a job, so that they are not economical on small lots.

It is customary to draw wire springs after winding to a dark blue color (about 500 to 550 deg. F.). This is termed "blueing." It tends to relieve the strains due to the winding, and also provides more or less protection against oxidation in case the springs are not to be japanned. However, a japanned finish is the usual one for wire springs, and it so happens that a japan which bakes at 500 to 550 deg. F. has just the right elasticity and toughness for spring use. Therefore the operation of baking the japan also serves to draw the springs. In modern wire spring shops the japanning ovens are built large enough to accommodate a small truck fitted with racks, on which the springs are hung after dipping, and the truck is then run into the oven and left until the baking is completed.

#### COMPOSITION OF STEELS FOR COILS

Coil springs of alloy steel are heat-treated in practically the same manner as elliptics. The analysis of steel used, either carbon or alloy, is about the same as for elliptics, although carbon steel for coils should preferably run above 1.00 per cent in carbon rather than below.

The manufacture of cold-wound coils is an entirely different matter. You cannot coil 1.00 per cent carbon

steel cold, even though you carefully anneal it. Therefore several special grades of "carbon spring wire" are used for making such springs. Most important of these are oil-tempered wire, and hard-drawn or "black premier" wire. The former is a wire running about 0.50 per cent carbon and 0.50 to 0.50 per cent manganese, and is heat-treated directly after passing through the wire dies and before winding on the reel, by being passed successively through a muffle furnace, a quenching bath and a drawing bath or furnace. This tempered wire can then be wound cold on practically any size of mandrel, and can even be battered with a hammer until the wire is bent almost double on itself without breaking. At the same time it is good for a torsional stress of 110,000 to 115,000 lb. per sq.in., in  $\frac{5}{16}$  in. or  $\frac{3}{8}$  in. round, and a much higher stress in smaller sizes.

Hard-drawn wire is a material of about 0.30 per cent carbon, which has not been annealed after the last few passes through the wire-drawing dies. It is not tempered either before or after winding. This at first sight would appear to be a very low grade material for spring making, but as a matter of fact it produces very satisfactory springs if the stress required is not too high. It is rather apt to be non-uniform, a condition which I have been told is usually due to failure to replace the wire-drawing dies as they become worn.

Another grade of spring which used to be common was bessemer wire, used for making cheap furniture springs. I know about this material only from hearsay, as there never was a pound of it in any shop with which I was connected. I believe it is now going out of use.

In addition to these carbon wire grades and one or two others which are used for special purposes, chromium-vanadium and silico-manganese steels in the usual wire spring sizes can be wound cold, and in sizes around No. 15 and smaller can usually be wound after tempering. These alloy steels, when intended for manufacturing into wire springs, should be electric furnace or crucible products.

#### TORSIONAL THEORY OF COIL SPRINGS

Next I want to say a few words about coil spring design, and will first point out that with experience and attention to detail it is possible to obtain very accurate results from the application of coil spring theory to practice; much more so than in the case of elliptics. The stress is considered as pure torsion, the small transverse load component being neglected. For compression springs of round bars the formulæ are:

$$(1) \quad \text{Load} = P = \frac{S \cdot d^3}{8M} \quad \text{and}$$

$$(2) \quad \text{Deflection per coil} = \Delta = \frac{8PM'}{Gd^4}$$

Substituting the formula for P in the deflection formula, we have:

$$(3) \quad \Delta = \frac{S \cdot M'}{Gd}$$

S is the torsional stress produced in the outer fibers of the section by the load P. M is the mean or pitch diameter of the helix, d is the diameter of bar, and G is the torsional or shear modulus.

Then if the stress S is taken as the maximum allowable for the material, formula 3 will state the maximum value of  $\Delta$  for the dimensions examined; further,

if the spring is to be capable of testing solid (coil to coil), the value of  $\Delta$  from formula 3 will also be the "maximum allowable space" or opening between adjacent turns of the spring.

Likewise, formula 1 will give the load carried by the spring when coil to coil; or, as it is usually called, the "capacity" of the spring. The total movement of the spring is the space between turns times the number of active turns. The tapered ends of the spring, being dressed down flat, have no movement, and must not be counted as active turns. Many spring designers overlook this point and get into trouble. There is a wide difference of opinion among authorities as to the proper values for  $S$  and  $G$ . About this more in a moment.

The formulæ for coils of square and rectangular sections, as given in most of the text books, are fundamentally wrong. They are based on the assumption that these sections retain their shape under torsional stress; whereas you can see in an instant, by twisting an ordinary rubber eraser, that the section becomes warped. The true theory was announced by St. Venant, the French mathematician, who worked out the formulæ for a rectangular section (of which the square is a special case) and for the triangle and ellipse. The problem is a very pretty one in the Theory of Elasticity. It is set forth more or less fully in several English works—I think that of Prof. Burr of Rensselaer Polytechnic is the most complete. The equation for rectangular sections involve infinite series of hyperbolic functions, and are difficult to turn into usable shape. But to illustrate the error in the old formulæ, these give for square sections:

$$P = 0.4714 \frac{Sd^3}{M}; \text{ and } \Delta = 4.712 \frac{PM^3}{Gd^4};$$

whereas the correct values are:

$$P = 0.4161 \frac{Sd^3}{M}; \text{ and } \Delta = 5.58 \frac{PM^3}{Gd^4}.$$

An interesting result of the St. Venant torsion theory is that the points of maximum stress in a rectangular section are the middle points of the long sides—in other words, the points on the periphery nearest the neutral axis; whereas the old theory assumed that the maximum stress occurred at the points furthest from the neutral axis, i.e., at the corners.

#### EFFECT OF OVERSTRAIN ON ELASTIC LIMIT AND SHEARING MODULUS

A few curious things have been developed by research work on coil springs. In the first place it must be explained that in hot-coiled work it is customary to wind a spring so that it will have a free height considerably higher than the free height specified for the finished spring, this excess free height being removed as "permanent set" in the solid test. In railroad springs the excess free height is from 25 per cent to 100 per cent of the total movement of the spring after the excess height has been removed by the solid test. The average figure is about 50 per cent. The result of this practice is to increase materially the capacity and total movement of the spring. Take as a concrete example the outside coil of a Pennsylvania Railroad class H-24 spring, the dimensions of which are:

Outside diameter = 6½ in.  
Free height (final) = 8 in.  
Size of round bar = 1½ in.

If this spring were wound 8 in. high, it would test down to about 7¾ in. Other results would be about as follows:

| Free Height As Wound. | Free Height After Test. |
|-----------------------|-------------------------|
| 7½ in.                | 7½ in.                  |
| 8 in.                 | 7½ in.                  |
| 8½ in.                | 7½ in.                  |
| 8¾ in.                | 8 in.                   |
| 10 in.                | 8½ in.                  |

By winding the spring 11 in. high, we could perhaps gain another ½ in. in final free height, but the springs would probably be crooked after testing.

At the same time, an increase in winding height gives an increase in the capacity of the spring, but the increase in capacity is not as great proportionally as the increase in final free height. Thus we have increased the apparent elastic limit of the material. What has actually happened is this:

Let Fig. 2 represent the end view of a round bar fixed in a torsion machine, and let the line  $OA$  represent two radial elements in the same longitudinal plane and at opposite ends of the bar. Now suppose one end of the bar twisted so that the element  $OA$  at that end takes the position  $OB$ , the other end of the bar being fixed. Assume that the peripheral distance  $AB$  exactly corresponds to the shearing strain in the material when stressed to the elastic limit. Then the element  $OB$  will return to the position  $OA$  when released, as none of the fibers have been

stressed beyond the elastic limit. But suppose the bar twisted until  $OA$  takes up a position  $OC$  beyond  $OB$ , and fix a point  $D$  which is twisted around to  $E$ , the curved distance  $DE$  being equal to  $AB$ . Then all fibers between  $E$  and  $C$  have been stressed beyond the elastic limit,

and tend to take permanent set; while the fibers between  $O$  and  $E$  have not passed the elastic limit, and tend to return to a position  $ODF$  on release.

But in attempting to take up this position, the fibers between  $D$  and  $F$  are sheared past each other. This shear is entirely distinct from the shear between adjacent cross-sections, which is the only one considered in the usual torsion theory. As a matter of fact, these two shears—the one between adjacent sections attempting to maintain the element in its position  $ODF$  and the other between adjacent fibers of the same section and tending to return the element to its original position  $ODA$ —are opposed to each other. The element will then come to equilibrium in some hypothetical position  $OH$ . In other words, we have raised the apparent elastic strain limit of the bar in the ratio of  $AB$  to  $HC$ .

I have never attempted to construct a mathematical formula defining the position  $OH$ . It is not strictly a

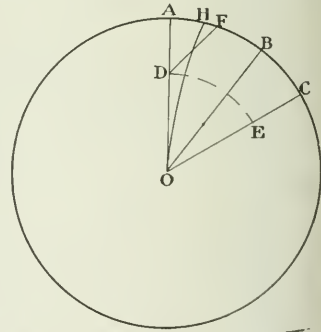


FIG. 2. ROUND BAR IN TORSION

mathematical problem, as we must know first the exact position of  $F$  in terms of  $AB$  and  $AC$ , which in turn involves the behavior of the material under stresses exceeding the elastic limit.

Now you can see what has happened to the H-24 spring, when tested down from an original height of 9 or 10 in. If wound to a height of  $7\frac{1}{2}$  in. the true elastic limit would not be exceeded and the spring would not lose any height in testing. If wound 9 in. high, it took a set, but the "apparent" elastic limit and the free height were considerably increased over that of the spring wound at  $7\frac{1}{2}$  in. as a result of the application of overstrains.

As soon as I got to work in the laboratory on this "theory of overstrains," I discovered some curious facts. In the first place, they reduce the life of the spring. An H-24 spring wound  $7\frac{1}{2}$  in. high will stand so many thousand solid tests before failure. If wound 9 in. high it will survive only about one-half as many solid tests; and if wound 10 in. high, only about one-quarter to one-third as many. Again, the raising of the apparent elastic limit by overstrains carries with it a reduction in the apparent shearing modulus. The diagram explains this at once; the modulus is a stress by strain ratio, the stress used being that in the outer fiber, and the ratio remains constant only so long as the original radial elements remain radial. This is the reason why you will find so many different values given in the text books for the shearing modulus as applied to steel coil springs. One will tell you it is 12,500,000, another 11,500,000, still another 10,500,000. As a matter of fact, the true modulus is 12,000,000 to 12,500,000; the apparent modulus may run down to less than 10,000,000 in a spring which is wound very high. In designing or checking a design, the apparent modulus has to be chosen with very careful regard to the height at which the spring is wound.

#### MOLECULAR HYSTERESIS IN OVERSTRAINED COILS

It is almost universal practice to make load tests of coil springs on "compression"—that is, going down from free height to solid height. But a few years ago the Navy Department decided that it would be well to have their springs tested on "release," i.e., coming up from solid to free. It immediately developed that the loaded height of most coil springs under any assigned load, if taken on release, was less than if taken on compression. A similar phenomenon is found in testing elliptics, but here the difference between the tests is obviously due to friction between the plates of the spring, which of course have to slide over each other when the spring is deflected. Some one then conceived the idea that in the case of coils the difference between tests was due to friction between the bearing surfaces of the spring and the plates of the testing machine, since a coil spring winds up slightly when it is compressed. So we rigged up a ball-bearing device to remove this friction, but it did not have any appreciable effect.

Then an investigation soon found that this difference between release and compression tests was related to my theory of overstrains. If the true elastic limit of the metal has not been exceeded in the original solid tests, there is substantially no difference between release- and compression-load tests. With increase in overstrain the difference in question increases rapidly, until with a

rather excessive overstrain it is about 25 per cent of the deflection of the spring under an average load. The explanation of the difference remains a mystery, but evidently there is a mechanical hysteresis present in overstrained coil springs.

That the phenomenon is due to some internal condition of the metal is indicated by the fact that we can wipe out a considerable proportion of the difference between tests by giving the spring a second draw after testing it solid at a somewhat lower temperature than the original draw. I stumbled on this fact by accident, and then made a complete series of experiments on it. The results obtained by this second draw are somewhat erratic, but one can always increase the height for a given load on release-test perceptibly, and usually the gain is about 50 per cent of the difference between tests when the spring is not given the second draw. Strangely enough, this expedient does not affect the compression test to any great extent, but only the release test.

Finally, I would like to mention an interesting verification of the theory of overstrains. It has been pointed out in connection with the St. Venant theory for rectangular bars in torsion, that the points of maximum stress are the middle points of the long sides. Evidently, then, when overstrains are applied to a spring made of square or rectangular bar, the proportion of the section which is overstrained a given amount is much less than in a round bar spring. We should therefore expect the elevation of apparent elastic limit to be more marked in square bar springs than in rounds. This is exactly the case. For rounds of  $\frac{1}{2}$  in. to 1 in. bar, the apparent elastic limit after large overstrains would run about 110,000 to 120,000 lb. per sq.in. for commercial work; whereas in squares of the same sizes and under the same conditions we could get 130,000 to 140,000 lb. per sq.in., and with rectangular bars of wide, thin section some almost fantastic figures can be obtained.

There is practically nothing about overstrains in text books as regards either springs or any other branch of mechanical theory. Certainly our knowledge of the fundamental truths underlying the Strength of Materials Theory is in a state far from satisfactory. My own idea is that the problem will be found to be a molecular or an atomic one, and chemists and physicists will have to come to the rescue. The man who writes the "Mechanics of a Molecule" or the "Mechanics of an Electron" will throw a flood of light into many dark corners of engineering theory into which we have to venture every day.

Crucible Steel Co. of America,  
Pittsburgh, Pa.

#### Licenses to Enemy Patents

The I. E. du Pont de Nemours & Co. of Wilmington, Del., filed application on Nov. 22 for the use of German owned U. S. patent rights on the following:

"Producing Ice Colors," "Stable Indigo-White and Process of Making Same," "Compounds of Leuco Vat Dyes With Aralkyl Compounds and Process of Making Same," "Reducing Indigo Coloring-Matters," "Aromatic Ammonium Compounds and Process of Making Same," "Azo Dyes from the Arylamids of 2,3-Oxynaphthoic Acid and Process of Making Them," and "Condensation Products from the Arylamids of 2,3-Oxynaphthoic Acid and Formaldehyde and Azo Dyestuffs Therefrom and Process of Making Same."



## Refractory Products\*

BY A. MALINOVSKY

REFRACTORY ware may be satisfactory in one furnace under one set of conditions, whereas it may not meet the requirements in another furnace with different substances and under a different set of conditions. Today many types of refractory materials are on the market in the form of bricks, crucibles, etc., which are manufactured from different substances for different purposes as required in various lines of industries. These refractory wares must resist different heights of temperature, depending upon the particular use to which they are put.

It has been demonstrated by different authors that some refractory wares will melt and frequently volatilize at heats where others remain intact, due to certain conditions existing within the furnace. Some refractories carry a load when exposed to a high heat at which others collapse. The success of refractories in operations where high temperatures are employed and the economical advantages to be derived from them are so intimately connected with the material employed in building crucibles or furnaces that it is important to know how to select a material possessing the properties which will enable it to withstand the required conditions. It is particularly difficult to obtain a material which will serve satisfactorily under conditions in which high temperatures are combined with the action of acid fumes, or alkalies, which act as a flux and produce chemical reactions tending to lower the refractory properties of the ware.

Refractories that are high in silica will carry loads at high temperatures satisfactorily, but are particularly susceptible to the combined action of heat and certain acids, alkalies or slags. A fire clay ware containing a high percentage of free silica, when it comes in contact with substances containing fixed bases, suffers a deterioration in its refractory properties, owing to the fact that bases will combine with free silica and will form fusible silicates at low temperature. The chemical effect of substances containing low fusible oxides of metals upon refractory ware, such as glass pots, crucibles or other utensils, is not always readily detectible and is due largely to the action of salt vapors and flue ashes.

Refractories should be composed of materials burned at high temperatures which are strong enough, when molded into ware, to hold at a high heat their contents and weights without distortion. A first class fire brick should carry a load of about fifty pounds to one square inch at 1350 deg. C. It is important for fire brick, especially, to reach their greatest degree of hardness and to contract to their full extent before they are used in a furnace.

The degree of fusibility of a refractory ware depends upon its chemical characteristics, its elementary composition and texture and its physical properties. In other words, fusibility is not only influenced by the elements which enter into the combination of the substances and the proportion in which they are combined, but also by the properties of the compounds or mixtures of various minerals. It appears that the property of

easy fusibility in refractory material depends, first, upon the nature of the complex compound bases such as the alkaline earths and the oxides of metals; second, upon the proportion which exists between silica and alumina; third, upon the shape and fineness of the grains; and, fourth, upon the physico-chemical changes which take place when the material is under fire.

It is well known that the alumina is the clay base which forms one of the most highly refractory materials when the content present is high enough to resist slagging and heat actions. It is such material that is extensively used for commercial and technical purposes. The refractory quality of fire clays is increased by the addition of finely ground bauxite or flint clay. It must be understood that not all bauxites and not all flint clays are suitable. Pure materials must be had and they are of limited quantity.

Refractories may be divided into three different classes, acidic, basic and neutral. I think that purely acidic or basic conditions very seldom exist in a furnace, if ever at all. Acidic refractories are made from pure quartz known as ganister, or quartzite. As silica possesses no plasticity, it has no binding property. Some manufacturers use clay as a binder, though it is not a very satisfactory binder for silica brick. The colloidal clay shrinks enormously upon heating and the silica expands considerably. When the brick is reheated, the silica will continue to expand and the clay to contract. These two physical properties work contrary to each other, producing a porous, ware having a very weak and loose structure.

The best results are obtained with lime, which is used the most at present. From 1 to 2 per cent of lime is added in the form of milk of lime. Mixed with the finer silica particles, it envelops the coarser silica grains and at high heat sinters the grains together into a strong body in the form of a net-like structure through the mass. Some authors state that the flux forms calcium monosilicate,  $\text{CaSiO}_3$ , which is known as wollastonite. However, the writer believes that there must be different calcium silicates present in the magmatic solution of a silica product. The best results in the manufacture of silica brick are obtained by heating the brick to cone 20, at which temperature the greatest part of the silica is converted to cristobalite and tridymite. It can be said that nearly all the fire clays are acidic, as the silica is dominant in nearly all of them.

Basic refractories consist of magnesite, dolomite and limestone. Limestone has high refractory properties, not being fused or softened (except in the electric furnace), but on account of the properties it possesses, in that the calcium oxide readily reacts with  $\text{CO}_2$  to form calcium carbonate and crumbles, it has never come into great commercial use. Dolomite is calcined, ground and mixed with tar, molded under pressure and heated to a high temperature. The calcined dolomite is also mixed with slag and used in the open hearth furnace, by merely throwing it into the furnace with a shovel, to protect the walls of the furnace.

Magnesite requires a greater heat for calcining than limestone or dolomite to expel all the carbon dioxide and is usually exposed to white heat. After cooling it is ground and mixed with a low calcined magnesite or some other binder and then molded into brick under enormous pressure with a hydraulic press and heated

\*A paper read at the meeting of the American Chemical Society, St. Louis, Jan. 7, 1918.

to a very intense heat. Magnesite is very refractory and resists metallic action, but fuses readily in contact with silica. The same is true of limestone or dolomite. Magnesite is a good heat conductor and is for this reason very suitable for metallurgical work as well as for the lining of electric furnaces. Magnesite brick under load at high heat will collapse. When exposed to sudden changes of temperature, it spalls very badly on account of its density and friability.

Neutral refractories are those which resist silica and basic oxides. Graphite, chrome and some bauxite with pure fire clay mixtures are representative of these. Bauxite in its raw composition is a hydrated alumina, containing a varying proportion of impurities, as silica and iron. On heating, the water is driven off and the impurities, as silica and iron, increase in quantity, which tends to nullify the refractory quality of bauxite. The content of water varies from 6 per cent to 34 per cent and that of iron from 1.5 per cent to 30 per cent. Bauxite before it is used must be calcined at a very high heat, from 1200 deg. C. to 1350 deg. C., and again must be repeatedly heated before all the contraction has been obtained. Carbon refractories are made by mixing graphite or charcoal or coke with a good plastic fire clay and burning at a high heat. Oxidizing conditions must be avoided when carbon ware is burned.

Chrome brick, made of chrome iron ore, is a very valuable refractory, as it has the property of resisting both acid and basic slags. Therefore, it is used in furnaces as a neutral lining between acidic and basic refractories. The writer has had experience in open hearth furnaces where silica bricks were placed directly upon magnesite bricks. Where the two different refractories come in contact with each other, a protective layer of calcined dolomite from 12 to 18 inches thick is placed so that the heat cannot be raised to flux them. Chrome brick is very valuable in repairing furnaces when they are under a high heat, as it resists sudden changes of temperature, but will fail and give way at high temperature under high loads the same as magnesite.

Refractories are also made from rare minerals containing zirconium, thorium, yttrium and beryllium oxides. Among these zirconia is the most developed for refractories, as it has a very high melting point, nearly 2000 deg. C., and resists all acid and basic slags. Its heat conductivity is very low. Zirconia is produced from the mineral known as baddeleyite from Brazil.

A very important factor which must not be overlooked is the mortar in which the bricks are laid. Refractory bricks made from fire clay should be laid with the same clay the bricks are made of, mixed with fine ground brick or grog to decrease the contraction. The mortar for laying silica brick should be very high in silica and low in alumina and other impurities as iron, lime, etc. Magnesite brick should be laid with magnesite mortar or with dry magnesite powder.

Care should be taken when building furnaces to select the right kind of material and mortars, especially in open hearth regenerators, blast furnaces, cupolas and coke ovens, where the mortar may give away and the strong draft deposit the destructive cinder slags in the joints, where they accumulate and, acting as a flux, fuse large cavities in the brick, thus weakening the whole structure. Therefore, if we test the refractory ware

against cones, we should test the mortar at the same time, as it should be borne in mind that a high aluminous mortar for silica brick will act as a flux and slag the brick. The alumina content should be by no means greater than 10 per cent. We also have to keep in mind that refractories with a close texture and fine grain will the better resist abrasion, attack of fluxes, fumes, vapors, slags, flue dust, etc. Refractories with open structure and coarse grain will best stand sudden changes of temperature, but will disintegrate very quickly in contact with salt fumes, slag, flue dust, etc.

As seen from the foregoing, texture is a very vital point. It is well to know where and in which part of the furnace it is most suitable to use brick with a close texture.

I believe that if all engineers, chemists, metallurgists or any firm using ceramic wares would join the American Ceramic Society, many of the defects of present ceramic wares could be eliminated. The society will be of great value with its membership of trained technical and practical men who are capable of solving the difficulties which confront those engaged in any line of industry using fire brick or stone ware. Many firms believe that any college-trained chemical student who is able to make an analysis of clay should be capable to work out ceramic problems. Technical men with a chemical and scientific education will be lost in ceramics until they have had practical experience. It is a great mistake to employ students (as I have seen in most iron and steel works) with the expectation that they are equipped to work out ceramic problems.

It is beyond the ability of the average chemist to conduct a proper analysis of a clay. An analysis of such complex substances as clay, or any other ceramic material, should be made by experienced ceramic chemists. We should welcome heartily the wider knowledge and the progress in ceramics which will attend the growth of the American Ceramic Society.

Lincoln, Ill.

### To Expedite Demobilization of Soldier Chemists

As hostilities cease we naturally must again turn to peace-time conditions and look forward to the future development of chemical industry in America. The problem now before the Industrial Relations Branch of the Chemical Warfare Service is to assist chemists in service to secure positions where their training and experience can be used to the best interests of the Government. This enormous readjustment is rendered possible through the information gathered by Dr. Charles L. Parsons, secretary of the American Chemical Society, and through the questionnaires sent out by Major F. E. Breithut of the Personnel Division of the Chemical Warfare Service.

To accomplish results chemists now in military service who desire to return to chemical industry are being requested to inform the chief of the Industrial Relations Branch concerning their future prospects, and manufacturers are being asked to designate their requirements for chemists. The administration of this work will be carried out by the Industrial Relations Branch and information may be obtained by writing to Major Allen Rogers, Chief, Industrial Relations Branch, Chemical Warfare Service, 7th and B Streets, N. W., Washington, D. C.



## Quicksilver Operations at Monte Amiata, Italy

The Italian Deposits Were Opened in the Twelfth Century, but Were Dormant After the Crusades Until 1860—Most Important Operations at Present Are at Siele and Abbazia San Salvatore—Preparation of Ore Furnaces in Use

BY DR. ROLAND STERNER-RAINER<sup>1</sup>

**D**ISCOVERIES of stone hammers, arrowheads, wooden plates and coins made upon opening the old workings around Monte Amiata show that these mines were worked for cinnabar by the Etruscans and later by the Greeks and Romans. (These relics are preserved in two small museums by the managements of Siele and Cornacchino.) At Morone some mining was carried on in the twelfth and thirteenth centuries. War and pestilence closed the mines and they were reopened only in the middle of the last century. They gained importance but slowly because of the tremendous production of California. From 1860 to 1874 only the Siele works were in operation. One year later the Solforate Schwarsenberg began producing in a small plant which was closed in 1885. Cornacchino produced in 1880, and in 1887 Reto or Monte Buono followed suit. Twelve years later the plant of Abbazia San Salvatore was opened and in the following year took over the abandoned Corte Vecchia. In 1906 the Siele plant opened the deposits of Solforate Roselli, in 1908 those of Petrineri, near Bagni San Filippo, and in 1909 those of Morone, near Selvena.

### SITUATION OF WORKINGS

At present the district of Monte Amiata embraces seven plants belonging to five companies, and the Cerreto Piano property at Pereta is being developed.<sup>2</sup> The new "Merkur" company, financed by the banking interests of Bleichröder, of Berlin, have been endeavoring for the past year to prove the extension of the old ore body in the trachyte district south of Abbazia San Salvatore. These efforts, though extensive, have been unsuccessful so far.

None of the plants is situated on a railroad. The nearest railroad point is Monte Amiata, on the line Grosseto-Asciano-Siena, from where the 20-kilometer mountain road leads to Santa Fiora, picturesquely situated on the banks of a stream of the same name which flows along the southern slope of Monte Amiata. After covering an additional 15 kilometers, Abbazia San Salvatore, Siele, Catellazzara and Cornacchino are reached. A second railroad point is Chiusi, on the Rome-Florence Railroad, from where a 40-kilometer road leads through vineyard and chestnut groves to the various plants.

The most important deposit is that of Abbazia San Salvatore, situated on the east slope of Monte Amiata,

a well-wooded mountain of 1734 meters elevation. The deposits lie in a north and south direction, as do those of the other properties. The mineralized zone<sup>3</sup> is found in the lower Jurassic, the Eocene and the Pliocene sandstones. It has been found that the ores are richer and more abundant the more argillaceous the limestone and the nearer to Monte Amiata. Since the ore is horizontally disposed and outcrops at many points, meteoric waters "filter" into the mines, giving rise by chemical reactions to a strong evolution of carbon dioxide and hydrogen sulphide gas. Excepting the two most northerly mines, Abbazia San Salvatore and Petrineri, all of the mines suffer to a greater or less extent from this evolution of gas.

### SAN SALVATORE MOST IMPORTANT

In the beginning of the '80s the German geologist Dr. Schwartzberg studied the region about Monte Amiata, and finding cinnabar in the creek gravel of San Salvatore, acquired property in the neighborhood for mining purposes. For several years an open cut was worked, when the dwindling ore reserves necessitated deep mining. In a short time the primary ore body was located. The geology has not been completely worked out, but new light will probably be thrown on the geological relations when this ore body has been opened on deeper levels. Ever since then the mine has grown in importance and has long been the most important of the district, producing 20,200 flasks of quicksilver in the last year, as against 19,880 flasks of the previous year.

The faces of drifts and crosscuts are sampled before stopping is begun, as the clay often hides the cinnabar, making it difficult to judge the ore by eye. Besides this average ore, which constitutes the greater tonnage mined, a rich shoot of 30 per cent ore is being stoped. Despite the enormously greater tonnage of average ore, one-fourth of the mercury production is derived from the high-grade ore. Rich pockets are worked individually. The ore is hand-sorted underground and premiums are given to the miners to insure their interest in the sorting process. The minimum content of the sorted ore is placed at 12 per cent, while the average content is around 18 or 20 per cent. This ore is trammed to drying floors and furnaced separately, as it is believed that longer roasting is necessary for higher grade ores. All ores are trammed to the "deposito," on a centrally located tramping level; the ore is lowered to the tram

<sup>1</sup>A portion of a paper on "The Present Status of Quicksilver Metallurgy in Europe," translated by C. N. Schuette from *Osterreichische Zeitschrift für Berg- und Hüttenwesen*, Vol. 62, 1914, p. 529. The translation was made in connection with a coöperative investigation of the metallurgy of mercury being carried on by the Bureau of Mines and the New Idria Quicksilver Mining Co., and published by their courtesy.

<sup>2</sup>Z. pr. Geol. 1914, No. 1.

<sup>3</sup>A. Verri, *Il Monte Amiata*, Boll. Com. Geol. Ital., Vol. XXII, p. 9; P. de Ferrari, *Le miniere del mercurio del Monte Amiata*, Florenz, 1890 (with bibliography); E. Lotti, *Die Zinnober und Antimon führenden Lagerstätten Toskanas und ihre Beziehungen zu den quartären Eruptivgesteinen*, Z. pr. Geol., 1901, p. 41; V. Spirek, *Le gisement de cinabre de Monte Amiata*, Publications du Congrès Internat. des mines, etc., Liege, 1905.



level through offset chutes and is hoisted from the lower levels.

At the reduction plant the ore is dumped on a grizzly of 80 x 100-mm. mesh. The wall rock is hand-spalled and does not have to be dried before being charged to the shaft furnaces. The material that passes the grizzly is fed into the rotary drier, shown in cross-section in Fig. 1, and in perspective in Fig. 2. The temperature in the cylinder is never more than 150 deg. C. The drying gases (generated by burning

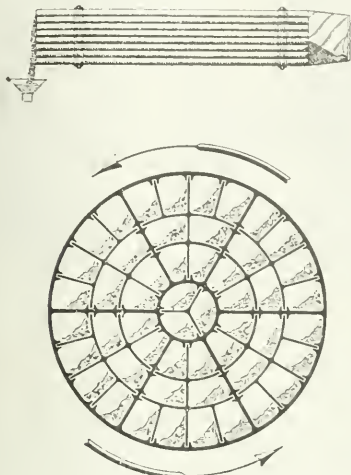


FIG. 1. CROSS-SECTION OF ROTARY DRIER

brush) pass through the drier in the same direction as the ore, and at first contact with the wet ore they are cooled to such an extent that quicksilver losses are not to be feared. A thermometer inserted into the overlapping casing indicates the temperature fluctuation. Screens are fitted to the end of the drum which classify the dried ore into plus and minus 40-mm. sizes. The coarse ore, a hard limestone with a 0.4 per cent mercury content, always equals just one-half of the fines; the fine ore, a mixture of argillaceous dust, clay nodules and shattered limestone, has a content of 0.9 to 1 per cent mercury. The capacity of the drier is 7 tons per hour, the moisture content of the ore being reduced from 15 to 4 per cent. Four men work on the grizzly; one man fires the drier, and two men draw the dried material. A total of 32 men is needed to dress the ore.

#### DUST COLLECTED AND SAVED

The moist, dust-laden drier gases pass into a settling chamber where most of the dust is recovered. The last remnants of dust are arrested by a water spray in a second chamber, after which the gases escape. The collected dust is loaded into cars with a belt conveyor and is taken to a wet dressing plant, which seems justified, as this dust would otherwise go to waste. Thirty tons of dust per month are concentrated to a slime carrying 40 to 50 per cent mercury. This slime is treated in two Ferraris furnaces (a hand reverberatory with inclined hearth) and recovers 24

flasks of mercury. The loss in concentration is estimated to be 12 to 16 per cent. It is planned to burn this dust together with all minus 5-mm. material in a rotary kiln furnace built in a manner similar to the rotary drier. From this kiln the gas will pass into a settling chamber, and from this settling chamber will rise the pipes leading to the condensers. If the trials prove successful, several of these kilns will be erected.

The high grade ore and the wet concentrate are dried on drying floors. This was the original method of drying all ores. As was common in the district, the ore was air-dried under roofs, sun-dried and later, with increasing production, the ore was dried on a sheet iron floor, heated from beneath by the hot gases from a grate fire. Since excessive drying caused mercury losses and as the handling of the ore was not only costly and time-consuming but also unhealthful, the former director, F. Ammann, built a "shaft-drier" as far back as 1903. The ore was charged at the top and descended over a zigzag of iron plates. Each knee contained a slit, allowing the moisture to escape into the drying gases. Ammann also originated the four "drying canals," which are not in operation at present, being kept in reserve. These drying canals are heated tunnels, 1.3 x 1.4 meters in cross-section, and 80 meters long, the ore losing its moisture when run through this tunnel on cars having perforated sheet-iron bottoms.

The dried ore is sampled before further treatment. The run-of-mine ores are sampled several times monthly for rough control. The gold cover assay method was used. The pulverized ore is mixed with a small quantity of granulated copper, and heated in a crucible. A half-gram sample suffices for high-grade ore, one to two grams are taken for low-grade ore, while 0.2 gram is

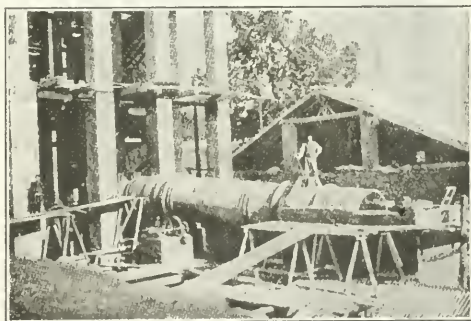


FIG. 2. ROTARY DRIER IN OPERATION

sufficient for pressed soot. The average assay value of the ore treated is 0.8 per cent mercury.

#### FURNACE PRACTICE AT ABBADIA SAN SALVATORE

At present the plant consists of 14 Spirek shaft furnaces and 6 Cermak-Spirek fine-ore furnaces. The shaft furnaces, Fig. 3, are of identical construction, the

<sup>1</sup>From a letter from Director Trögel, Abbadia San Salvatore, we hear that the kiln has been in experimental operation for two months and that the results have led to several modifications of the plant. When these have been tested—say in the first part of 1914—it will be decided whether this kiln shall be duplicated or whether the Cermak-Spirek furnaces shall be equipped with producer-gas firing, as has been done in Idria. For notes on the use of a rotary kiln at New Idria, Calif., see *Chemical & Metallurgical Engineering*, Vol. 19, p. 239 (Sept. 1, 1918).

circular shaft, 1 meter in diameter, being built of local trachyte. Each has a capacity of 7 tons per 24 hours, 1.5 per cent of charcoal being added to the charge for fuel. An automatic feeding device of local construction insures a fumeless charge-hole.

Four of the fine-ore furnaces which together treat 10 per cent of the ore have a capacity of 25 tons, and two have a capacity of 12 tons per 24 hours. The cinnabar concentrates and the pressed soot are furnaceed with the hand-sorted high-grade ore, these charges being more carefully controlled and burned twice as long as low-grade ore. Sluicing of tailings at two-hour intervals is customary in the district by using creek water flowing under the draw doors of the fine-ore furnaces. Only the coarse ore tailings are carried to a dump which has so nearly reached its maximum size that it is proposed to utilize these tailings to fill the mine workings.

Sixty men are necessary to operate the furnaces, the wages ranging from 3.10 to 3.80 lira.<sup>a</sup> The wood is supplied by 18 men.

All furnaces are equipped with Cermak condensers, the parts of which are made by a clever potter of Castellazzara, who furnishes these pipes even to American plants. The soot boxes are arranged, as is customary, perpendicular to the line of the condensers, allowing the first inverted U-pipe to be cleaned every month, while the others are cleaned only at the main clean-ups. All soot found in the system on the furnace

sary draft, while one is kept in reserve. With a consumption of 7.7 horsepower, a rotor diameter of 800 mm. and a speed of nearly 1000 r.p.m., they move 212 cu.m. of air at 21 deg. C.

It may be mentioned that an attempt was made at this plant to shorten the time of bottling the product by measuring the volume instead of weighing the mercury. (Fig. 5.) For this purpose Director Ammann



FIG. 4. STONEWARE EXHAUST VENTILATORS

constructed a suitable apparatus and designed curves, giving the volume of various temperatures. This method, however, could not replace the apparently tedious weighing process, because the small gain in time was offset by the inaccuracy caused by the unavoidable temperature variations during the manipulation.

Losses do not worry the management at Abbadia San Salvatore; in fact, the output of mercury is greater than the indicated ore content obtained from the sampling and assaying. It is not possible to say where the error is made without an intimate knowledge of the method of calculating the input. Considering the clean and careful operation of the plant, one would probably not be far wrong in placing the loss at 9 per cent, the figure obtaining at Idria, with which plant it can most readily be compared both as regards ore content and scale of operations.

#### OPERATIONS AT SIELE

Siele is the second largest producer, with 150 tons of mercury per annum. The ore body is exploited through the mine in the valley of Siele and through the younger Solforate Roselli mine, which lies across the watershed on the drainage basin of the Fiora. The Siele deposits are nearly exhausted, and in a few years the Solforate will probably furnish the entire ore, which is transported to the reduction plant by a cable tramway. In Siele itself the neighboring property is in other hands, which, according to the Italian mining law, is a bar to further development. These ores, in argillaceous limestones of the upper Eocene, are richer than at any other mine in the district, as this crumbly material was most favorable for the deposition of cinnabar. Even though the average ore content is more than 2 per cent mercury, richer ores than these impregnations are found only in small quantities, and it is necessary to sample the ore in place to determine its content, since the cinnabar color is almost completely hidden by the rock. The moisture content is 20 to

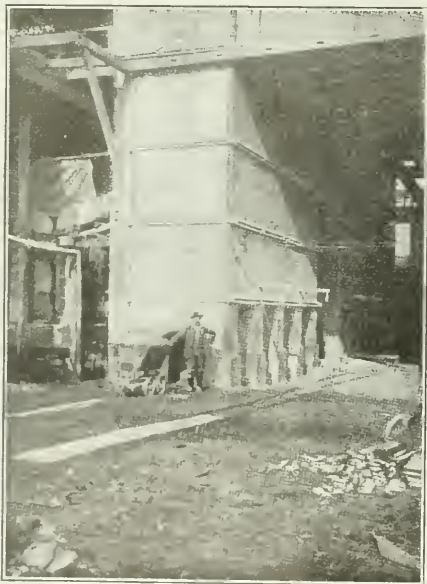


FIG. 3. SHAFT FURNACE AT ABBADIA SAN SALVATORE

side of the exhauster is treated in Exeli soot presses, the mercury content being reduced from 50 to 15 or 20 per cent. The plant has three stoneware exhausters, Fig. 4, installed by the Ton- und Steinzeugwerke of Berlin-Charlottenburg. Two of these induce the neces-

<sup>a</sup>A lira is equal to \$0.193.



25 per cent, as this is one of the wettest mines. This is also the reason for the gas exhalations and the absence of gypsum, which, excepting for a few small crystals, appears to have been leached away.

After the ore has been dried on drying floors it is passed through two crushers, as the entire tonnage is treated in fine-ore furnaces at present. A 24-ton, a 12-ton and a 3-ton furnace (which burns the pressed soot and the very high-grade ore) suffice to treat the entire present tonnage. The 24-ton furnace treats only 18 tons per day, as the high percentage of fines necessitates a 30-mm. interval between tiles. The 12-ton furnaces, however, can treat 13 tons in 24 hours, as the heating flame penetrates the flues more readily. The disposal of the tailings is also accomplished by means of creek water. The furnaces are cleaned monthly, and the soot of the small furnace treating the rich product is gathered every two weeks. An electrically driven soot mill and the two storage pots equipped with siphons

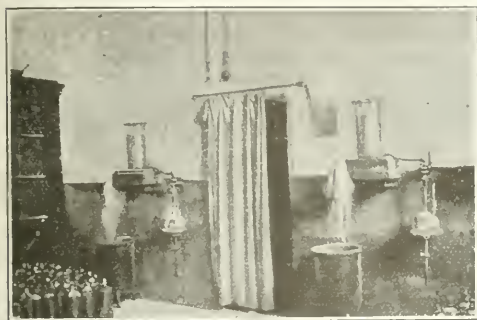


FIG. 5. AMMANN'S MEASURING DEVICE

complete the equipment of this little plant. Formerly, when the dried concentrate was treated in retorts (of which two or three were combined into one branch), the losses were high, but they are today estimated at 5 per cent of the input. The cost per flask of metal is 140 to 145 lira (\$27 to \$28).

#### CONDITIONS AT CORNACCHINO

Mining conditions at Cornacchino are even less favorable. Cornacchino is situated near the village of Castellazzara in the drainage basin of the Paglia (Tiber), near the intersection of the provinces of Grosseto, Rome and Siena. The mine belongs to "Eredi Schwarzenberg," as does a mine situated some distance to the west across the hills, near ruins of Castle Roccaccia. Both of these mines have their own reduction plant. The ores of Cornacchino are siliceous schists impregnated with cinnabar. The original ore body, which was in limestone, had very much richer ore than those mined today, but it has been completely worked out.

During the '80s these ores were burned in shaft furnaces and retorts. It was only when the Cermak-Spirek furnaces became known that the porous and fragile cinnabar bearing siliceous schists of the foot wall could be treated economically. The treatment of such fine ores in retorts or reverberatory furnaces

seemed economically impracticable with metal contents as low as 0.35 to 0.4 per cent.

The ore as mined is fairly dry and no artificial drying is needed, as is necessary at most of the other plants. The coarse ore amounts to about one-fifth of the fine ore, so that at present one 24-ton fine-ore furnace and one shaft furnace are used; the latter, however, is in intermittent operation through lack of coarse ore. The developed ore reserves insure a ten-year life of the mine at the present rate of production. The plant can continue operation only if new ore bodies are developed and if wages and the price of wood do not increase further.

The process of dressing the ores which contain 7 to 8 per cent moisture consists of screening them into plus and minus 40-mm. sizes. The minus 40-mm. material contains 0.35 per cent mercury, and the plus 40-mm. material contains but 0.05 per cent mercury. A sample is taken from each car of the screened material as it is brought to the furnace. A twenty-four-hour sample is crushed and assayed for mercury and moisture. Seven to eight grams are used for an assay, which is prepared with zinc oxide and hammerscale, as at Idria. The shaft-furnace feed is not sampled. The burnt rock is sampled in the morning and in the evening just before ore is drawn in the fine-ore furnaces. About 20 grams of this are used for an assay. The shaft furnace soot is very rich despite the poor grade of the ore treated by these furnaces; the ratio of free mercury to mercury in the soot is 1 to 3, while at the fine-ore furnaces only 17 to 20 per cent is recovered as free mercury. The pressed soot from the shaft furnace still contains 28 to 50 per cent mercury. The plant (which is working with a loss of 15 to 20 per cent) produced 1200 flasks during 1912, including 2500 kg. of mercury from the shaft furnace. The cost of production was 150 lira (\$29.15) per flask. Sixty-eight men were employed in the mine and sixteen in the metallurgical plant.

#### MODERN SPIREK FURNACES AND CONDENSERS AT MORONE

The ore deposits of Morone lie in the nummulitic limestone and at the contact of limestone and shale. The ores, which average 1 per cent mercury, are therefore very argillaceous. Because of the great quantity of water which aids the rock disintegration, a considerable volume of gas is evolved. The run-of-mine ore contains between 15 and 20 per cent moisture.

Since this plant was erected only a few years ago, Spirek's successor, following the fundamental ideas of his uncle and teacher, was enabled to apply all of his experience in its construction. Since the method of operation of nearly all the quicksilver plants of Tuscany is based upon the experience of the two Spireks, it might not be out of place to discuss the results.

In the development and improvement of the fine-ore furnaces it became manifest that the 24-ton furnaces, which use 12 per cent by weight of the input of fuel, are economical where beachwood is available. Other varieties of wood, such as oak, chestnut or fir, are not as suitable for this size of furnace because of the shorter flame, which does not suffice to completely burn the ore. With the 6-ton furnaces the ratio of ore to fuel is the same. Even though they necessitate more labor as com-



pared with the larger furnaces, they are very popular for high-grade ore and pressed soot, as complete roasting is more readily obtainable in them. The 12-ton furnace burns only 10.2 per cent of any kind of wood; the roast is complete, so that it may be used to furnace all ores.

A coarser or granular feed allows the space between tiles to be a little larger than with the dusty feed, the flame can more easily penetrate the flues and, since the cinnabar on these ores is deposited superficially, it is more easily and completely sublimated; this allows 26 tons to be treated in the 24-ton furnace without increasing the loss. With dusty or argillaceous ores the space between tiles is only 35 mm. (Abbadia San Salvatore and Morone 35 mm., Siele 30). Since these latter ores are generally richer, the slightly lessened tonnage is not very noticeable. It would pay to determine the degree to which the roasting must be carried so that the value of mercury driven off at the last is still slightly greater than the amount of fuel needed to drive it off, as it is possible that in current practice at Monte Amiata too much time and heat are used to extract the last small quantities. The upper row of inclined plates in the furnace is made of cast iron; in Siele the second last row has also been made of cast iron to prevent damage when charging. These upper rows of tile serve to seal the furnace charge, preheat and dry the charged material and are not themselves heated. The two lower rows of tile serve to preheat the air for combustion, and are not heated either. With the 12-ton furnaces the draw doors are placed along the short side of the furnace with the fire box, so that the first row of tile will be more evenly heated, while with the 24-ton furnaces the draw doors are situated on the long side of the furnace. The exit pipe is made of cast iron 4.5 meters long, as is also the first descending leg of the condenser. The flange connections of these pipes, packed with asbestos and red lead, have proven superior to sleeve couplings.

#### CONDENSERS OF FURNACES

A 24-ton furnace has ten parallel condenser lines, a 12-ton furnace has five, and the small 6-ton furnace has three. The large furnace has two small, separate condensers to draw off the moisture and charge gases from the upper two rows of tile. The two smaller furnaces are built with one such separate condenser. Three wooden soot-boxes of cedar, into which the U-pipes of the condensers dip, are arranged perpendicularly to the direction of gas flow. More than three of these condenser units are not necessary; flues and chambers of a large cross section, which reduces the gas velocity, are more efficient for the collection of soot.

Up to a furnace capacity of 36 tons per day, one square meter of chamber cross-section is sufficient, while above this capacity it must be correspondingly enlarged. The necessary draft of about 5 mm. of water is obtained with a Root blower. If the last inverted U of a condenser line shows a slight pressure when the cover is removed, the draft is considered correct. One damper is situated just before the exhaust and regulates the entire gas stream.

<sup>\*</sup>(Translator's note) The tile referred to are the tile shaped like an inverted V of the Cermak-Spirek furnace, often referred to as "gable tile."

The first and second soot boxes are cleaned once a month, the third every three months; the cleaned mercury is drawn every fourteen days. The floor of the plant is cemented and has a network of gutters to catch any scattered mercury. Soot from different localities is pressed separately, as by doing this it is thought that a better extraction is obtained. The pressed soot retains about 15 to 20 per cent mercury. The soot from the hot part of the iron exit pipes is poor and so dry that water must be added to it so that the quicksilver can be pressed out. Soot from the first box contains 80 to 85 per cent mercury, soot from the second box about 70 per cent, and that from the third 45 per cent. In the first chamber the soot contains 30 per cent, and this soot is also sent to the soot press. Poorer soot is mixed an equal part of ore and charged again. One man can work out 30 flasks of quicksilver in an eight-hour shift. The empty bottles, which are numbered and weigh 4.5, 4.6 or 5.5, or a maximum of 6 kg., are weighed before filling, as is also the mercury; the filled bottles are again weighed.

The reduction plant of the Morone lies on a terraced slope about 500 meters from the adit mouth. In summer the ores are sun-dried, in winter they are dried on drying floors to a 4 per cent moisture content. The clay is cobbled from the limestone pieces, and the latter are hand-dressed to the desired size. The clay rock is fed into crushers, the product of which—ore containing 1 to 1.2 per cent mercury—goes without exception to two 12-ton fine-ore furnaces. The lump ore containing 0.3 per cent mercury is burned in two Spirek shaft furnaces, which are iron-sheathed, as was customary with the Caillaux furnaces in use forty years ago in this district. The work is carried on in three eight-hour shifts; two men per shift are needed to operate one fine-ore furnace and one shaft furnace. Since the material charged at this plant is fairly dusty, all three soot boxes are cleaned monthly, the first chamber being cleaned every three months. The mine employs 135 men, the metallurgical plant 45. The average monthly production of the last year was 200 flasks and this year has been increased to 350 flasks, so that the year 1913 may show a total production of 114 metric tons of mercury. In view of the high-grade ore the plant loss is estimated at only 10 per cent of the input.

#### SMALLER PLANTS IN TUSCANY

The plant at Bagni San Filippo, Petrineri, treats its ores which contain 0.4 to 0.5 per cent mercury in two 12-ton furnaces and one twin shaft furnace, after they have been dried from a high percentage of water, in a manner similar to that employed at Morone. Thus far the financial aspect of the venture, in which 110 workmen produce 60 flasks of quicksilver per month, was not very promising. Recently gas exhalations encountered in the mine give rise to the hope that the primary ore body, which has not thus far been located, will soon be encountered.

The smallest plant is that of the Monte Buono mine, which treats its ore in a 24-ton fine-ore furnace. The ore is a sandstone impregnated with cinnabar running 0.2 to 0.3 per cent mercury. It is sufficiently dried by handling, and being a somewhat decomposed rock, is crushed with wooden mallets. The soot is mixed with

lime and treated in retorts to prevent the formation of soot from the soot. During the summer, the plant, which otherwise produces 40 flasks per month, is closed because the 80 miners are really farmers and work on their farms during this time.

The occurrences of antimony-quicksilver ores of the Maremma grossetana, which extends from Selvena over San Martino and Capita in a southwest direction to the Tyrrhenian Ocean, are closely associated with the above cinnabar ore deposits. The mine of Selvena, which is producing black bituminous lower Jurassic limestones impregnated with cinnabar, antimony-glance and pyrite, has been abandoned. The ores of San Martino, a red-colored, brown iron ore impregnated with cinnabar, occurring in thin Eocene strata, impregnated with antimony-glance, have no commercial importance. The same is true of the old mine near Capita at Capalbio, the ore deposit of which lies in the Rhatkalk near the contact of the Eocene.

### Colloids and Flotation

United States Bureau of Mines Technical Paper 200, "Colloids and Flotation," shows the application of certain facts of colloidal chemistry and physics to practical flotation operations. Some of the unexplainable troubles in the flotation plant can probably be explained by the facts that have developed in the study of colloids. They draw attention to the fact that at times some sulphides are not wetted by water and under other conditions are wetted. The last case is, of course, an abnormal one, and when this condition obtains flotation is impossible. It can probably be explained by the phenomena of adsorption. The adsorption phenomena are an effect due to surface energy. Surface energy is a product of surface tension multiplied by area. Therefore, the adsorption phenomena are affected by any factor that tends to increase or reduce surface tension. The surface energy and adsorption effects for solids can only be proven by analogy of the action of liquids and gases.

Willard Gibbs developed a thermo-dynamical formula to show that adsorption is due to a concentration of molecules in the surface of solids or liquids and that it can be either positive or negative. Therefore any material that will give negative adsorption for water, say, would probably give positive adsorption for gases. Impurities in solution tend to upset surface energy conditions and would cause positive adsorption for gases to be changed to negative adsorption for them. As adsorption is manifest by wetting or non-wetting in our case, it is seen that under certain conditions some sulphides can be wetted by water and others not.

In dealing with a solid, water and oil phase the action of adsorption toward the solid will be the algebraic sum of the surface energies of all the material entering into the sphere of action. Hence any substance that tends to upset the surface tension or energy of any one of the three or four phases involved would tend to change the resultant surface energies of all of them and hence upset the conditions that have been established for adsorption of either the water or the gases involved, as the case might be. Therefore, it can be seen that any impurities in solution in the water would tend to affect this algebraic sum and hence upset the necessary equilibrium necessary to float the sulphides

from the pulp. Also, as the surface energy is the product of the surface energy multiplied by the area, the presence of any material having very largely developed surfaces which is of course principally colloidal would tend to upset the equilibrium and hence flotation.

As size is such an important factor, it is plain too that the oil can be too much emulsified. In fact, when the oil is in an extremely colloidal condition it is impossible to get good flotation results. The fact that the same materials which tend to throw the oils out of emulsion are substances that benefit flotation is a proof of this statement.

A practical illustration of some of these things is the case at Inspiration, where it was found to be impossible to float the copper sulphide from the gangue containing large amounts of decomposed material such as koaline, which is of course a colloid. No trouble was encountered, however, in locating the hard undecomposed ore.

There are several different types of colloids, but the most important are the so-called irreversible and reversible colloids. The irreversible colloids are those that are most liable to be present in ore pulps, being iron, aluminium hydroxide, etc. They are called irreversible because it is impossible to put them back in colloidal condition after having once flocculated them by means of an electrolyte.

The reversible colloids are those that can be put back into colloidal condition by simply shaking up after flocculation. They are very inactive toward electrolytes. Among the reversible colloids might be mentioned aqueous solutions of gelatin, glue, gum, tungstic acid and molybdic acid. These materials cause great trouble in flotation and are very difficult to remove.

From this short discussion several conclusions might be drawn. Among them are that colloids interfere greatly with flotation and that in order to overcome the difficulty they must be removed. There are several ways of doing this, among them being preliminary heating of the ore, washing the ore or flocculating it by means of electrolytes. These are, of course, the means of removing irreversible colloids. As far as is known, there is no way at present of overcoming the difficulty due to productive colloids or reversible ones.

### The Graselli Prize

At the meeting of the N. Y. section of the Society of Chemical Industry, on Oct. 25, the honorary secretary, Major Allen Rogers, announced an annual prize in the form of a medal to be given to the author of the paper of the greatest general interest and value presented at any meeting of the New York section of the society during the year. The donor of the medal is the Graselli Chemical Co. and it is to be known as the Graselli prize.

### Ramsay Memorial Fund

More than \$3,000 had been contributed to the Ramsay Memorial Fund in the United States up to Nov. 1. It is hoped that the American subscription may reach \$10,000 by Jan. 1. Checks should be made payable and sent to the Ramsay Memorial Fund Committee, W. J. Matheson, treasurer, 2 Burling Slip, New York City.

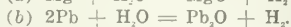
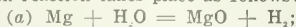


## Synopsis of Recent Chemical and Metallurgical Literature

**Magnesium Lead Alloys.**—In a paper read by MR. E. A. ASHCROFT before the Faraday Society at the London meeting in July, 1918, the disintegration phenomenon herein noted, and any prospect there may be of technical utilization of such alloys and their properties, are all based on the accidental discovery made in the course of some other researches of very remarkable properties which are possessed by alloys of metals of the magnesium type with metals of the lead type. The alloys of magnesium with lead—for instance, an alloy of 15 per cent magnesium with 85 per cent lead—will rapidly and completely oxidize in the cold if exposed to atmospheric oxygen and moisture, being then converted rapidly into a “jet-black” powder having the composition of magnesium hydrate and lead sub-oxide or its hydrate. The reaction is complete in a few hours. The water present up to this stage of the reaction does not take any part in the oxidation of the metals, and is not itself decomposed, but combines with the oxide of magnesium and the sub-oxide of lead to produce hydrates, the oxygen absorbed by the metals being obtained from the atmosphere.

For atmospheric oxidation, alloys of 15 per cent Mg are preferable to those of higher content, as the richer alloys (*e.g.*, an alloy of 35 per cent Mg and upward) will not oxidize readily in the cold. By use of this reaction, if sufficient of the alloy be exposed to combine with all the oxygen in any confined space, every trace of oxygen may be removed from any gaseous mixture containing it. It seems therefore possible that such alloys might find useful application both in the laboratory and also in small commercial operations for manufacturing nitrogen from the air and for removing oxygen from any gaseous mixture in the cold. Such a process might, for instance, economically take the place of the last rectifying tower at present used in the large-scale manufacture of nitrogen for conversion to ammonia cyanides or nitrates by liquefaction and fractional distillation of air.

But one may also utilize these magnesium-lead or like alloys for the production of pure hydrogen gas for aircraft or other purposes. For this purpose alloys richer in Mg may be employed, and 35 per cent is a convenient strength. It is only necessary to boil such alloys in water, when reaction takes place as follows:



The reaction (a) takes place briskly. The lesser reaction (b), however, under these conditions proceeds only very slowly, and if it is required to render it rapid and complete, it is preferable to digest the alloy under a steam pressure of 100 lb. to the square inch and a corresponding temperature of about 150 deg. C., when the lead will be completely oxidized to  $\text{PbO}$ , and the theoretical quantity of hydrogen liberated. The hydrogen may be drawn off from the pressure vessel with the steam and collected. From the mixture of hydrates or oxides of magnesium and lead resulting

from the reactions also numerous useful products may be obtained.

The hydrates especially are extremely reactive substances, and are obtained in most suitable condition for subsequent further reactions. For many purposes the mixture of hydrates of lead and magnesium may be used without separation. But separation of the magnesium oxide is also easy if required. As an example of possible utility of the residues, the manufacture may be cited of lead peroxide, which according to the known reaction may be easily produced by passing chlorine gas into water in which is suspended a mixture of  $\text{PbO}_2\text{H}_2$  and  $\text{MgO}_2\text{H}_2$  in molecular proportions. The oxidized alloys may also be employed for the preparation of other lead salts or compounds, and would seem to form a most convenient base for this purpose. For instance, a very fine quality of basic lead carbonate (white lead) may be obtained very easily by acting on the lead hydrate with carbonic acid, either with or without separation of the magnesium. The white magnesium carbonate would probably be no detriment to this product as a pigment, but rather the reverse, as it seems to improve its covering and its drying properties. Litharge and minium may also be obtained from the material very readily, and, if desired, of great purity and excellent physical properties, by simple processes.

The mixture of oxides resulting from the oxidation of these alloys may therefore form a valuable starting-point for other manufactures, and in some instances (such as lead peroxide and white lead) it would seem probable that its use may be economical and may constitute substantial improvements in the known processes of manufacture of these products.

To prepare the alloys of magnesium and lead any convenient method may be employed; for instance, magnesium and lead may be readily fused together under a cover to a temperature of 700 to 800 deg. C., and after mixing thoroughly, cooled out of contact with the air, when complete alloy will be found to have taken place, and the product can be readily broken up. Or magnesium may be precipitated from its salts into the lead by employing alkali metals or alkali metal alloys.

But to render the production of such alloys specially economical it is proposed to electrolyze anhydrous magnesium chloride (which is now being produced commercially and very economically by the process for which British Letters Patent 12,873 and 13,259, both of 1916, were granted) over a cathode of molten lead. In such manufactures the electric energy required is the chief item of cost, and consumption is only 2,000 kilowatt hours per ton of 15 per cent alloy. Thus where electricity is very cheap these alloys can be obtained practically at nearly the same cost per ton as metallic lead, and the resulting useful products and effects may be obtained with a considerable degree of economy.

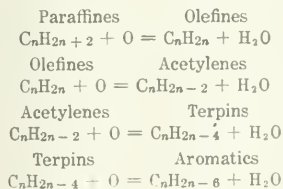
These alloys furthermore possess the valuable feature that they may be produced where electric energy is cheap, and then transported cheaply in sealed cans and utilized at any remote situation. Thus, for instance, as a source of hydrogen or nitrogen for aircraft or for localized manufactures of ammonia or nitric acid, the cost of transport of the alloy would be only a small fraction of the equivalent cost of transport of the products, or of an equivalent quantity of gases in cylinders. For example, the weight of material transport required to



produce a given quantity of hydrogen at any remote situation will be only as 1 to 6 and of nitrogen as 1 to 10, when compared to the transport of cylinder gases. Also the wear and tear and capital sunk in cylinders and the cost of compression are all obviated. These are very substantial advantages to set against the cost of the alloys, but to them must also be added that in most instances the solid products of decomposition of the alloys are as valuable as (and sometimes much more valuable than) the alloys, so that the gases are obtained as by-products and substantially free of cost.

**Dehydrogenation of Petroleum Oils.**—Dr. A. S. RAMAGE in the *Canadian Chemical Journal* of August, 1918, gives an account of a commercial method of making volatile motor oils from the high boiling point paraffines without decarbonization, part of which we quote:

In my process my endeavor has been not to crack the oil, but to obtain a definite chemical reaction, namely—the dehydrogenation of the paraffine to the olefine. In other words, our product is a motor fuel which practically is 95 per cent olefine—the other 5 per cent being further unsaturated products. Water is always produced in dehydrogenation, and is condensed and separated from the fuel in the receiving tank. The reaction can be carried as far as the aromatic series, depending entirely upon the temperature and length of tube through which the vapors are passed. The reaction is as follows:



The vapors are passed over heated iron oxide  $Fe_2O_3$ . At the temperature for motor fuels of 620 deg. C. the oxygen is taken up with the reduction to the oxide  $FeO$ , at which stage we stop the action, steam out the oils remaining in the oxide for five minutes and re-oxidize with a current of air for fifteen minutes. We are very careful not to allow the reduction to go beyond  $FeO$ , because if metallic iron is formed, cracking immediately takes place with deposition of carbon. The action of dehydrogenation is endothermic, whereas the reoxidization is of course exothermic. The period of dehydrogenation lasts for three hours in practice and the revivification one-half hour.

Our first production was in a laboratory tube, electrically heated, 2 feet long, followed by a tube 3 inches in diameter, 4 feet long—then by a tube 10 feet long 3 inches diameter. Our conversion of the original oil would always run 36 per cent, once run through the tube. Since then we have extended the tube to 24 feet and our conversion averages 90 per cent of the original oil, and the recovery 94 to 95 per cent. No carbon has been produced. After steady running of eight months, the iron oxide was removed from the tube and not a trace of carbon was found in it.

The works were built at River Rouge on a practical scale. After several fires, it was burned down and a new works has been erected at Ecorse.

Furnaces containing tubes 8 inches in diameter and 22 feet long are now adopted as the best length and diameter with the feed of ten gallons per hour per tube. For a motor fuel to correspond with the present ordinance for gasoline, a temperature of 600 to 620 deg. C. is kept in the lower half of the tube. The waste heat from the oil burners heating the lower half of the muffle is led off at the upper end of the furnace, giving a temperature of 400 deg. at the upper end where the oil enters to 600 deg. where the vapors issue. We have found that by this progressive heating of the tube the product is not scorched and comes out of the condensers a deep straw color, whereas the passing of the oil or vapors immediately into 600 deg. C. causes the product to become dark and contain some tar. Progressive heating is one of the features of the process. A simple distillation of the condensate with 1 per cent fuller's earth is sufficient to refine the spirit. If we raise the temperature to 650 deg., we obtain a product running as high as 50 per cent under 120 deg. C. and at 680 deg. C. practically all of our product comes over with an end point between 120 and 130 deg. C. I mention this fact because of its application to not only the aeroplane industry but the production of low boiling olefines as a starting point in the organic chemical field.

It is perfectly feasible and does not add materially to the cost to obtain 80 per cent of the original oil with an end point of 45 deg. C. being composed of amylene and low boiling point olefines. One particular point about olefines is the wonderful solubility of ethylene in them. Ethylene is produced in quantity when we are running to obtain very low boiling point spirits, and the gas is compressed and passed through the spirit under pressure of 100 pounds to the square inch. Fifteen times the volume of ethylene is absorbed, and the peculiar point is that after releasing the pressure the ethylene is not given off at normal temperature but seems to be held in some loose form of combination, because at between 40 and 50 deg. C. it begins to come off in great volume. The fact that this gas is dissolved in the motor fuel in such loose form connection as to be so readily given off probably accounts for the quickness with which this fuel ignites, even below zero.

Of more interest to chemists are the products obtained upon further dehydrogenation. Practical results have shown us that with the tube length of 50 feet, and a feed of ten gallons per hour, from 20 to 30 per cent toluol can be produced, not counting the other aromatics. In toluol production the upper end of the tube is kept at 400 and the lower end at 750 deg. C. In the conversion of xylol,  $C_8H_9(CH_3)_2$ , as high as 72 per cent has been obtained of the benzol-toluol fraction containing 30 per cent benzol; the balance toluol. In the separation of aromatics from olefines present the usual sulphuric-acid treatment is followed. I find, however, that this reaction which has always been used is very incorrect and not more than 20 per cent of olefine is reacted upon, the balance of the olefines being polymerized to high boiling point olefines. It can be seen by the simple dehydrogenation of the petroleum oils we are in a position to produce olefines, acetylenes, terpins and the aromatics, and from these bodies the alcohols and various organic products.

## Recent Chemical and Metallurgical Patents

**Universal Soap Dyes.**—Fast on cotton, linen, wool, silk or mixtures.

Dyes for use in coloring textile fabrics in the household laundry have been long on the market. Recently new developments have been made in the manufacture of these materials, a description of which is found in the patents recently allowed to CHARLES C. HUFFMAN of Chicago, Ill. Browns from copper to chocolate shades; blues from baby to navy; reds through flesh pink, rose, salmon, orange, old rose, lavender and purple; yellows and greens, are all compounded from four prominent commercial coal tar dyes: aniline acid red, methylene blue, chrysoidin yellow and a direct black.

Mr. Hoffman states that his improved dye soap should not be confused with those in which the soap acts merely as a carrier or vehicle for the dye, as peculiar reactions take place between the dyes used and the soap, which give a different product than hitherto obtained. One of the important distinctions of the new dye compound is that it is alkali proof, irrespective of the prior basic, acid or neutral characteristics exhibited by the dye before combining with the soap.

A still further distinction is that these dyes are universal, that is, adaptable directly to either cotton, linen, wool, silk or mixtures thereof. The greatest advantage, however, is that temperature, time and concentration of the dye suds do not influence the depth of shade; therefore no special skill is required in matching pieces treated separately.

In producing forty-five pounds of soap dye, about twenty-five and one-half pounds of olive, soy bean, raisin, peanut, corn or any vegetable oil are saponified in the cold with thirteen and a quarter pounds of sodium hydroxide solution (sp.gr. 1.40 at 65 deg. F.). When the reaction is nearly complete, one gallon of boiling dye solution is added to the incompletely saponified oil soap emulsion. The heat of the reaction together with the heat supplied in the added boiling dye solution serves to raise the temperature of the mixture to approximately 122 deg. F., at which temperature the dye reacts with the free sodium hydroxide, forming a sodium salt of the dye acid with the elimination of a molecule of water. The formula of the resulting dye has not been determined; none of the reactions characteristic of the dye acid remain, however, so that a new compound is thought to exist.

In ordinary solutions, chrysoidin yellow will precipitate aniline acid red and the latter will throw methylene blue out of its solution. In making browns by this process, all three of these dyes exist in solution simultaneously. A medium shade of brown is produced by adding to the emulsion a quart each successively of the following boiling dye solutions:  $7\frac{1}{2}$  oz. chrysoidin yellow,  $7\frac{1}{2}$  oz. aniline acid red, 5 oz. direct black and  $\frac{1}{2}$  oz. methylene blue. Greens are prepared by adding 2 quarts of boiling chrysoidin yellow solution followed by a like amount of methylene blue. The intensity of the various shades depends on the amounts of dye acids compounded into the soap emulsion and the colors on

their relative proportions, so that color matching will not be left to the skill of the user. (July 30, 1918; 1,274,046-017-048-049.)

**Separation of Alunite from Gangue.**—CARL F. HAGEDORN of Chicago notes that the specific gravity of alunite and its associated rhyolitic gangue is so nearly equal as to prevent gravity concentration. He therefore recommends a preliminary calcination of the material, crushed to  $\frac{3}{4}$ -inch, in a rotary kiln operating at about 1000 deg. C. The kiln and temperature should be so adjusted that practically all of the  $\text{SO}_2$  is driven off during the two or three hours the particles are in the kiln. High temperatures are to be avoided, since they volatilize potash. The inventor specifies that the fuel shall be oil, gas or other non-silica bearing material, noting the fact that the fine ash from pulverized coal adheres to the calcine and fluxes the various constituents in such a way that further separation is retarded. After calcination the gangue material is of its original texture but the alunite has been disintegrated so that separation in many known ways is easy. Simple screening is suggested for the separation of the fine alumina and potash from the coarser particles of rhyolite. A particularly advantageous method of separating the potash consists in digesting the calcined materials in an autoclave at about 60 pounds pressure and a temperature high enough so that the contents may not cool below 90 deg. C. until after they have been filtered. Only sufficient water is introduced to take the  $\text{K}_2\text{O}$  in saturated solution at 90 deg. C. After digestion the sludge is separated from its coarser and heavier particles of gangue in a V-box or de-watering cone, the overflow of which contains the finest and purest alumina in suspension and the potash in solution. (1,253,590 and 1,253,591; assigned to Mineral Products Corporation; Jan. 15, 1918.)

**Aluminates from Alunite.**—P. R. HERSHMAN of Chicago, Ill., has already patented (1,191,104) a method of obtaining soluble potassium aluminate from alunite. He has now discovered that practically complete extraction of the potassium may be had by the following process: Mix 30 parts of calcium oxide with 100 parts of pulverized alunite, heat the mass in a muffle to 1000 deg. C. in the presence of steam, when a water soluble compound corresponding to the formula  $\text{K}_2\text{O} \cdot 2\text{Al}_2\text{O}_3$  is formed. This is removed by leaching, and the potash-free residue containing about 60 per cent of the alumina may be further treated as follows: Barium sulphate and calcium oxide are each added to the residue in molecular proportions to the alumina contained, and the mixture heated in a muffle furnace for about three hours in the presence of superheated steam. The greater part of the barium and aluminium forms a soluble barium aluminate which may be extracted with hot water. The compound is of value as a ready source of pure alumina.

Barium aluminates of the formula  $\text{BaO} \cdot \text{Al}_2\text{O}_3$  or  $2\text{BaO} \cdot \text{Al}_2\text{O}_3$  may also be made of the residue from the sodium aluminate leach by mixing with barytes, together with considerably more carbon than is required to effect the reduction of the latter to the sulphide. The mass is pulverized to 100 mesh and is heated for four hours at 1050 deg. C. in a muffle furnace through

which is passed a slow current of reducing gas and steam. The excess carbon, steam and reducing gas maintain an atmosphere containing more or less CO, which is of use in preventing the decomposition of the barium aluminate by CO. During the operation elemental sulphur is driven off, which may be collected by known methods. (1,240,571-2 and 8; assigned to Armour Fertilizer Works; Sept. 18, 1917.)

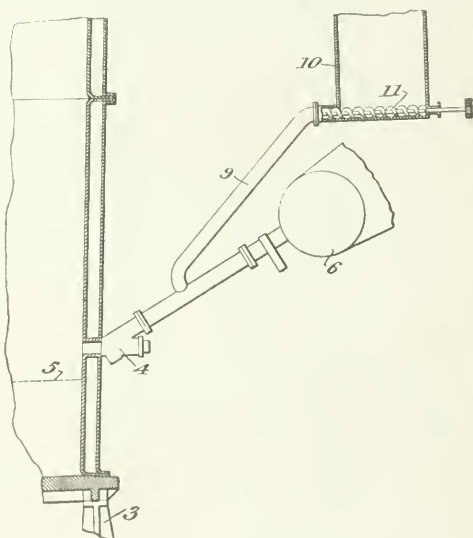
**Pure Alumina from Alunite.**—HOWARD SPENCE and W. B. LLEWELLYN of Manchester, England, note that the residue from leached calcined alunite contains so many impurities, such as iron and silica, as to render it unfit for use in metal or abrasive manufacture without further purification. They therefore propose to ignite the alunite in such a manner as to produce maximum solubility, to pulverize the calcine and to hydrate the mass in the cold for several weeks in liquor from a previous operation. The hydrated material is then agitated for a few hours in a series of closed vessels during the passage of SO<sub>2</sub>, maintaining a temperature of 40 deg. C. The solution is now tested for SO<sub>4</sub> ion, and any excess over 0.9 mols Al<sub>2</sub>O<sub>3</sub> is removed by the addition of the proper amount of lime. If there remains any excess sulphate the precipitated aluminium will contain basic double alkali aluminium sulphate and considerable alumina will remain in solution. After filtration, the clear liquor is heated out of contact with air, the SO<sub>2</sub> driven off is re-used, and over 90 per cent of the alumina is thrown down as a granular basic sulphate which filters easily. Practically all of the iron remains in the solution if air has been properly excluded. The precipitation is best effected in dilute solution containing about 5 per cent Al<sub>2</sub>O<sub>3</sub> to prevent the formation of double salts. The basic precipitate contains about 30 per cent Al<sub>2</sub>O<sub>3</sub>, and may be converted into the latter by ignition. (1,256,605; Feb. 19, 1918.)

**Potassium Nitrate from Alunite.**—H. J. DETWILLER of Allentown, Pa., proposes to digest powdered alunite with boiling nitric acid, taking into solution all the potassium and aluminium as nitrates and sulphates. Fine silica remaining may be removed by filtration and marketed for the manufacture of water glass or polishes. The aluminium in the filtrate is precipitated by the addition of KOH in quantitative amounts under constant agitation, and the aluminium hydrate removed by filtration. This is ignited into Al<sub>2</sub>O<sub>3</sub> and is ready for use in the manufacture of metal, alums or other chemical products. The clear liquor is agitated and boiled with a quantitative amount of powdered barium carbonate to remove the sulphate radicle. The precipitated barium sulphate is the well-known blanc fixe of commerce, of extended use as a pigment and size. Carbonic acid is now removed by the addition of nitric acid, and the remaining solution, containing only potassium nitrate, crystallized to saltpeter, used in explosive manufacture, fertilizers and chemical industry. (1,274,145; July 30, 1918.)

**Continuous Roaster-Extractor.**—W. M. E. GREENAWALT of Denver, Colo., patents a process of roasting and extraction, where the roasting is done in a vertical shaft of considerable height and with closed top. Across the bottom are a series of pipes perforated with fine holes, through which air and any other gas desired

to participate in the reactions are introduced. The roasted ore is passed between the tuyere pipes into a downward extension of the shaft submerged in a tank of water or other solvent, and is fed into the solution gradually by a mechanical feeder. A drag conveyor removes the leached ore, while the overflow removes fines and slimes in suspension in the solution. The method applies blast roasting so that the heat in the calcine is utilized to facilitate leaching, and losses of dusting are overcome. (1,218,996; Mar. 13, 1917.)

**Introducing Fuel Through Tuyeres.**—THOS. W. CAVERS of Copperhill, Tenn., patents the method of introducing all or part of the fuel needed in matte smelting in blast furnaces through the tuyeres, according to the diagram shown herewith. The bustle pipe 6 delivers air under pressure through the tuyere 4 into the furnace slightly above the slag line 5. Fine coal is discharged simultaneously from hopper 10 by means of



TUYERE AND FEEDING APPLIANCE

screw conveyor 11 and pipe 9. He finds that in working a certain sulphide charge semi-pyritically it has been necessary to add approximately 6 per cent coke to the ore and flux at the top of the furnace column. Except when starting the furnace, coke additions may entirely be supplanted in the new practice by approximately four per cent of fine coal, of inferior bituminous grade. Pulverization is not needed; the pieces of coal should be merely sufficient to allow uniform delivery without danger of clogging the piping. Sulphide ores, plus necessary fluxes, may also be introduced in this manner; fuel oil may be utilized instead of coal if it is more readily obtainable. In this manner the fuel is burned very close to the focus where it is needed, the focus is substantially lowered, and the top of the ore column is much cooler. The introduction of all or part of the fuel in the smelting of oxidized ores to a matte is also feasible; an oxidizing atmosphere must be maintained in the smelting zone, to prevent the formation of metallic "sows." (1,259,467; Mar. 12, 1918.)



## Aluminium and Its Light Alloys—VI

## Bibliography (b)

BY PAUL D. MERICA

THE following continuation of the Bureau bibliography on aluminium and its light alloys is the supplement to the very comprehensive one assembled by the library of the United Engineering Societies and presented to the Bureau by Professor Zay Jeffries.

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## Book Reviews

HANDBOOK OF CHEMISTRY AND PHYSICS. Fifth Edition, duodecimo (11 x 16 cm.), 414 pages; price \$2.00. Compiled and sold by The Chemical Rubber Company, Cleveland, Ohio, U. S. A.

The company employed Dr. W. R. Veazey and Mr. C. D. Hodgman, of the Case School of Applied Science, to select the data in their first edition; Prof. M. F. Coolbaugh of the same institution assisted Mr. Hodgman in the present revision. A large number of the tables have been revised, and numerous new ones added.

There is an immense amount of useful information between the covers of this book, and it is wonderful book-value for the money—as book prices go. But there is also a regrettable amount of misinformation mixed in with the good, a deplorable tendency to prepetuate ancient and honorable mistakes of earlier tables, and an exasperating absence of many well-known data. All the instances justifying this criticism cannot be catalogued, but examples of them are the following: The heats of formation comprise only three pages in large type, giving only part of Thomsen's results, which date from somewhere in the last century; not a single thermochemical value determined in the last twenty-five years is given. Many of Thomsen's values have been improved upon and hundreds of thermochemical data obtained since Thomsen died, but thermochemistry expired with Thomsen, as far as this handbook is concerned; furthermore, not over 10 per cent of the really important data determined by Thomsen are quoted in it. In the tables of physical constants of inorganic compounds, the melting



points of cerium, chromium, silicon and titanium are omitted as though unknown, those of magnesium, manganese, molybdenum, palladium, strontium and tantalum are given wrongly, in some cases several hundred degrees in error; tungsten is said to melt "above 1900 deg.," whereas for at least five years it has been known to melt above 3000 deg. Much of the information in this important table is ten years old or more, and frequently unreliable, in the light of more recent determinations.

The general characteristics of the tables containing miscellaneous information are the absence of the most modern or most accurate data, and their incompleteness. We regret to see students and practical men fed such scientific husks, because it inevitably leads to sloppy pseudo-science, which we had hoped was diminishing. There are better and more accurate chemical and physical handbooks on the market. In such a situation, the reviewer's advice would be to get the best or none; do not waste money on a book containing some unreliable tables, while purporting to give the most reliable data known.

**MINING ENGINEERS' HANDBOOK**, *Robert Peele*, editor-in-chief. First edition; 2375 pages;  $4\frac{1}{2} \times 7\frac{1}{2}$ ; red fabricoid; illustrated. Price \$5.00. New York: John Wiley & Sons.

The scope of this handbook is quite extensive, having besides the sections dealing with mineralogy, ore deposits, methods of prospecting, exploration and mining, and mining equipment, a good selection of civil, electrical and mechanical engineering subjects, economics and law. The staff of editors is very well chosen: mineralogy, A. J. Moses; geology and mineral deposits, J. F. Kemp; earth excavation, H. P. Gillette; explosives, Haskell, Holmes, J. a Motte and Le Maistre; rock excavation, H. P. Gillette; tunneling, Brunton-Davis; shaft-sinking in rock, H. L. Carr; shaft-sinking in alluvial soils, F. Donaldson; boring, A. F. Taggart; prospecting, development and exploitation of mineral deposits, J. F. McClelland; underground transport, E. C. Holden; hoisting plant, shaft pockets and ore bins, W. M. Weigel; drainage of mines, R. A. Norris; mine ventilation, F. E. Brackett; compressed air plant, R. T. Dana; electric power for mine service, G. R. Wood; surveying, Chas. B. Breed; underground surveying, Ed. K. Judd; mine geologic maps and models, R. H. Sales; mine organization and accounts, J. R. Findlay; cost of mining, J. R. Findlay; wages and welfare, E. K. Judd; mine air, hygiene and accidents, G. S. Rice; mining laws, H. V. Westervelt; mine examination, valuations and reports, W. Y. Westervelt; aerial tramways and cableways, E. B. Durham; mechanical conveyers, L. De G. Moss; ore dressing, R. H. Richards; ore sampling, T. R. Woodbridge; assaying, E. J. Hall; testing of ores, J. E. Clennell; notes on selling, purchasing of ore, A. L. Walker; gold amalgamation and cyanidation, E. A. Dufourcq; preparation and storage of anthracite coal, P. Sterling; preparation and coking of bituminous coal, H. M. Conner; mathematics and mechanics, C. H. Burnside; elements of hydraulics, J. K. Finch; engineering thermodynamics, E. D. Thurston; steam engines, boilers, pumps, turbines, gas engines, Parr, Thurston and Herrick; mechanical engineering, miscellany, Thomes and Parr; electrical engineering, W. I. Slichter; elements of structural design, J. K. Finch; general tables. While it has been customary to make engineering handbooks more or less dependent upon one another and to give thorough treatment in their limited field, the policy of this handbook is to furnish the mining engineer with a ready reference book on all subjects most likely to demand reference without regard to the other special handbooks he might be expected to have.

## Personal

MAJOR SAMUEL AVERY, chief of the university relations branch of the Chemical Warfare Service, resigned his commission on Dec. 1 in order to resume his duties as chan-

cellor of the University of Nebraska, Lincoln, Neb. This resignation has been permitted by the War Department at the request of the Board of Regents of the University of Nebraska. MAJOR VICTOR LENHER, in addition to his other duties in the relations section, now takes charge of the work relinquished.

MR. E. A. CAPELEN SMITH has been elected vice-president of the Chile Exploration Co. and the Braden Copper Co.

MR. H. C. CHAPIN has severed his connection with the National Carbon Co., Cleveland, Ohio, to become associate professor of chemistry in Lafayette College, Easton, Pa.

MR. W. DEWEY COOKE, secretary and sales manager of the Southern Fertilizer & Chemical Co., Savannah, Ga., has been commissioned first lieutenant in the gas and flame division of the Chemical Warfare Service.

DR. HERMAN FLECK has been appointed consulting chemical engineer of the Chemical Production Co., operating at Owens Lake, Calif. He will continue to act as consulting engineer to the Chemical Products Co. of Denver, Colo.

MR. ELLWOOD HENDRICK, consulting editor of *Chemical and Metallurgical Engineering*, read a paper before the New York Section of the American Chemical Society at Buffalo on "Chemists in the Future" at the meeting held Nov. 20.

MR. JOHN MCCONNELL, metallurgical and engineering adviser of the United Alloy-Steel Corporation, Canton, Ohio, has resigned. He is now connected with the Interstate Iron and Steel Co., Chicago, Ill., where he has charge of producing alloy steels.

MR. JOHN J. PORTER, first vice-president of the Security Lime & Cement Co., Hagerstown, Md., has been given a Government appointment as a dollar-a-year man. He is to act as potash expert for the Bureau of Mines and to help in working out plans for increased potash production.

MR. H. DEWITT SMITH has been appointed to a position with the Aircraft Production Board and will be stationed at Dayton, Ohio. He was formerly mine superintendent at the United Verde Copper Co., at Jerome, Ariz.

MR. HENRY P. WALTERS, recently in charge of the picric acid works of the Smet-Solvay Co., Split Rock, N. Y., has been selected to take charge of the new picric acid works now being erected for the Government at Grand Rapids, Mich.

## Obituary

MR. HOWARD S. LEE died on Oct. 25 of influenza at Silverton, Col., at the age of 38. Ten years ago he became associated with the United States Mining, Smelting & Refining Co., and since then had managed several properties of that company. Recently he had been promoted to the position of assistant to the chief consulting engineer, with headquarters in San Francisco.

## Current Market Reports

### The Non-Ferrous Metal Market

*Friday, Nov. 22.*—The non-ferrous metal market has not excited any interest, the war prices still prevail except in the cases of tin, zinc and antimony, the former of which is expected to continue to decline.

*Aluminum.*—The Government prices on ingots 98 to 99 per cent Al are \$660 a ton f.o.b. plant in 50-ton lots; \$662 down to 15-ton lots; and \$666 down to 1-ton lots, which prices will continue the remainder of the year. Prices per pound for small lots vary from 40c. to 45c.; sheet aluminium, 18 ga. and heavier, 42c.; powdered aluminium, 100 mesh, 70c.

*Antimony.*—The volume of sales is increasing at prices from 84c. to 85c. per pound.

*Copper.*—The price of \$520 per ton for carload lots and 27.3c. per pound for small quantities was continued for another period at the conference held on Oct. 25 at Washington.

|                            |     |        |           |
|----------------------------|-----|--------|-----------|
| Copper sheets, hot rolled  | lb. | \$0 36 | — \$0 37½ |
| Copper sheets, cold rolled | lb. | .37    | — .38     |
| Copper bottoms             | lb. | .44    | — .45½    |
| Copper rods                | lb. | .36    | — .37     |
| Copper wire                | lb. | .29½   | —         |
| High brass wire            | lb. | .28½   | — .29½    |
| High brass sheets          | lb. | .28½   | — .29     |
| High brass rods            | lb. | .26½   | — .28     |
| Low brass wire             | lb. | .32½   | — .34     |
| Low brass sheets           | lb. | .32½   | — .34     |
| Low brass rods             | lb. | .33½   | — .35½    |
| Braided brass tubing       | lb. | .37    | — .39     |
| Braided bronze tubing      | lb. | .42½   | — .44½    |
| Seamless copper tubing     | lb. | .41    | — .43     |
| Seamless bronze tubing     | lb. | .45    | — .46     |
| Seamless brass tubing      | lb. | .37½   | — .39     |
| Bronze (gold) powder       | lb. | 1 00   | 1 75      |

**Lead.**—The lead market is limited by selling restrictions, the supply being allocated by the Lead Committee. In car-load lots at East St. Louis, the price is \$155 per ton. In New York all speculative and traders' lead has disappeared. The Lead Committee apportions lead at 8.55c. to legitimate consumers.

**Manganese.**—The scale prices on page 629 of CHEMICAL & METALLURGICAL ENGINEERING, June 15, prevail; the highest price per unit being \$1.35.

**Silver.**—Due to the flow of silver to Asia in payment for munitions and the greatly increasing industrial consumption in photography, motion picture reels and silverware, there is a shortage of silver even at the present government price of \$1.01½ per ounce.

**Tin.**—The Tin Committee of the American Iron and Steel Institute has not yet announced the official price on tin. No doubt an understanding will have to be had with the producers before a final statement can be made public and as they are all in distant foreign countries, considerable time will elapse in intercommunication, with the added possibilities that prices will not be legally fixed but adjusted by economic conditions as to demand. The market is dull at a price of 71c. per pound.

**Tungsten.**—The market is quiet, scheelite bringing as high as \$25.50 per unit; wolframite, \$23.00 and off grade ores as low as \$17.00.

**Zinc.**—The spelter market is firm. East St. Louis is quoting \$164 to \$166 for November, \$160 to \$164 for December, \$158 to \$162 per ton for January. New York prices are from \$170 to \$174. Zinc dust, 13½c. to 16c. per pound. Sheet zinc, 15c. pound.

#### OTHER METALS

|           |        |               |
|-----------|--------|---------------|
| Bismuth   | lb.    | \$3 50—\$3 65 |
| Cadmium   | lb.    | 1 50—         |
| Cobalt    | lb.    | 2 50—3 50     |
| Magnesium | lb.    | 1 75—2 10     |
| Mercury   | 75 lb. | 125 00—       |
| Mercury   | lb.    | 1 95—         |
| Nickel    | lb.    | 40—43         |
| Tungsten  | lb.    | 34 00—        |
| Iridium   | oz.    | 175 00—       |
| Palladium | oz.    | 135 00—       |
| Platinum  | oz.    | 105 00—       |

### The Iron and Steel Market

The policy of the Government as to control of industry in connection with the transition from war time to peace time conditions has been quite fully outlined, but this does not determine the prospective course of the market. It is impossible to control trade completely, particularly when the control is intended to be exercised only for a limited period.

As to cancellation of contracts, the Government has adopted positively the policy of cancelling as rapidly as possible all orders for material that will not be needed, provided no work is being done upon the contracts, and of proceeding very slowly with the cancellation of contracts which are in course of being filled. On the one hand it is desired to save as much Government money as possible, while on the other hand it is desired to avoid idleness of plants and workmen.

As to limitations on the consumption of steel, placed to augment the supply of steel for war purposes, all restrictions have been practically removed, the earliest order being dated November 11, the day on which the armistice was declared, while other orders have followed in rapid succession.

As to restrictions upon producing operations, these have

likewise been removed in very large part. The preference list is canceled, and all priority orders, whether individual or automatic, except those involving orders placed by the Navy Department, Fleet Corporation and railroad, telephone and telegraph companies. Inasmuch as priority orders merely prescribed the sequence in which orders should be filled when it was impossible to meet requisite delivery dates on all orders, a very moderate relaxation in the pressure for steel would automatically remove the necessity for priorities. The usual contract between producer and buyer is restored and mills will fill orders in accordance with their own appraisal of the needs of their customers.

As to prices, nothing has been done. The maximum limits prescribed to obtain deliveries through December 31 continue in force. As the quarterly price fixings in the trade have carried no reference to the duration of hostilities or the war, no question came up as to the continuance of the limits to December 31.

#### FUTURE OF PRICES

Under open trade conditions, the natural tendency of the iron and steel market upon the ending of the war has been well understood in all quarters. The common view has been that prices after the war would average below the controlled prices, but whether or not that were to be the case a declining market for a few months would naturally occur, because a full measure of demand would not at once develop. A large proportion of the buying of steel in normal times is for investment purposes. Technically speaking, almost every purchase of steel is an investment. Even the jobber invests, expecting to re-sell, but he may convert his investment into cash within 30 days in some instances. The automobile builder invests and sells the finished car in 60 days or a longer period. Other manufacturing consumers, particularly those making seasonable goods, require longer periods. The investor who builds a factory the product of which has no certain sale for a period of years may expect to amortize his investment in three to five years. Another can look farther ahead. A highway bridge may be a safe investment if it cannot be written off in less than 20 years. Each class of buyers, therefore, has his own period in which he concludes the steel market will not decline, if he is to buy at the time instead of waiting for a lower market. There can be no stable market for steel unless there is demand approximately sufficient to engage all productive capacity, and a demand of that size requires that the major portion of it be for investment purposes, hence there can be no stable market until the balance of probability is that the market will not decline for such a period as the future can be gaged.

The object of control, therefore, is double, to prevent a temporary demoralization in the market, and to develop what is the price level at which the control can be renounced and the market allowed to support itself at that level. To prevent demoralization the view was held that the War Industries Board should for a time fix minimum prices, as it has hitherto fixed maximum prices. The first thought was that possibly the Sherman law stood in the way. The second thought has been that irrespective of the Sherman law, the Government in attempting to fix minimum prices would be abandoning one of its cherished traditions, that "the Government has never bluffed." It has never issued an order unless it could punish violation. When maximum prices were set the Government was in position to commandeer plants and put them on Government orders exclusively if the owners refused to sell at fair prices. It has no means to punish a price cutter. At this writing the common thought is, then, that the War Industries Board will continue to set maximum prices and if the trade can hold together it will adhere to those prices as minimum likewise. As long as the prices are maximum also, they must be kept fairly high, or inroads may be made upon the co-operative spirit that has been so pronounced. As they are kept high, however, the readjustment to lower levels is impeded. Accordingly a thought is rising that when the time comes the War Industries Board will not fix prices for the period after December 31, or if it does will fix them at such levels that the market will be free to depart downwards from them.



Immediately upon the signing of the armistice and the removal of various restrictions upon the production and consumption of steel there developed an insistent demand which has given the market an appearance of strength, but in this case appearances are misleading. The demand is insistent where it exists, but it represents but a small fraction of the total buying public, and only those buyers who see their way clear to liquidate the investment in a very short time. The chief demand has, in fact, come from jobbers and automobile builders. Together these buyers do not normally absorb 20 per cent of the steel output. The jobbing demand is not for the purpose of accumulating stocks, but of securing such material as can be turned over quickly, chiefly before January 1, on which date it is desired inventories should be as low as possible. The automobile builders have some stocks of steel and during the next few months will not require much more than their normal weekly or monthly quota of steel.

This flash of demand will soon be over, and while other buyers will begin to appear in greater volume there will be on the other hand the gradual cancellation of war orders and the balance cannot be struck until real investment buying develops. That will probably require several months at least and thus the balance of probability is that there will be a period of lessened mill operations. When the market has once been established to the satisfaction of investors there is likely to be heavy demand for steel for a period of years. Even in the case of the government itself, while the desire is to avoid a slump in the market, the Railroad Administration is definitely committed to a policy of not making further purchases until steel prices are lower.

### The Chemical Market

**HEAVY CHEMICALS:**—Trading in most all the items that come under this heading has developed a very conservative character and most consumers are averse to purchasing beyond their immediate requirements. Medicinal products again developed a firmer tone toward the latter part of the interval. General market quotations at the present, however, are considerably lower than previously indicated. Other products with but a few exceptions have had a downward tendency in price, particularly caustic soda, which has had a varied experience, though during the close a firmer market was in evidence, due to the possible lifting of the export restrictions which bring about buying interest for foreign account. Soda ash has also been neglected to a very noticeable extent and prices therefore have declined from 5c. to 10c. per hundred pounds, though conditions in the East continue to be somewhat more favorable than those in the West and Middle West.

**Caustic Soda:**—There is an unsteady undertone to the market at present, representing considerable diversity of opinion among traders as to the actual position of this product. Some holders who were offering at \$3.85 early in the week have withdrawn their quotations, although up to the close some material was available in scattered lots at this figure. The more conservative operators are closely watching the trend of the market, in view of the possible developments that may take place at any moment. Advances from the West state prices were advanced for the solid material from 4c. per pound to \$4.10 per hundred pounds, while in the East offerings were free at \$3.90 per hundred pounds ex warehouse. The ground product is also liberal in supply, but there is no particular buying interest in evidence and prices remain firm at \$5.10 per hundred pounds.

**Soda Ash:**—Conditions in this market have been somewhat easier for the past week and in most instances a decline in prices has been in evidence. Bag material during the latter period was generally quoted at from \$2.45 to \$2.50, while offerings of barrels were liberal at \$2.85 and \$2.90. Double bags from Western warehouses were quoted at \$2.85. In Chicago single bags were held at \$2.55 and barrels at \$2.85.

**Zinc Oxide:**—Buyers have been showing very little interest in the item and the only trading noted is that which is passing through routine channels. There are no price

changes reported and quotations generally range from 12½c. to 14c. per pound.

**Yellow Prussiate of Soda:**—There has been a continued depreciation in price for this material and quite frequently cheap lots are available, but despite this condition buyers are not attracted. Offerings of the product are made at from 36c. to 38c.

**Bleaching Powder:**—The government has removed all restrictions on the uses of chlorine and prices therefore have been on the decline. Quantities of the material were offered for bids, with sellers intimating that prices considerably below the market would be accepted, but there was no important trading. Prices for spot material range from 3½c. to 4c. and for that rolling 4c. to 4½c. was the asking price.

**Potash Chrome Alum:**—The market is reported to be quiet and the sales that are passing are consummated at the levels of 20c. to 21c., which continue to be the general quotations heard. Stocks are in fairly good supply and fully in proportion to the current call.

**COAL TAR PRODUCTS:**—Offerings of the products that come under this heading in most instances have developed to an easier position, but trading in general has been quiet during the past two weeks and that which is passing is only for immediate needs, with no disposition on the part of buyers to purchase ahead, owing to the uncertain conditions prevailing. The more conservative operators are just holding back, watching the trend of the market. No important price changes are noted in spite of the continued lull in the situation. However, where effected they have had a downward tendency. As soon as the contemplated cut in ammunition output is established, toluol will be available and the movement will open a wide field now practically closed.

**Toluol:**—Up to the present there is no reportable change of any importance in this market. The item is still under government control and there are no additional releases being granted. However, it is generally believed that all requisitions for December shipment will most likely be fulfilled. Some lots occasionally appear in the resale market at prices above those fixed by the government.

**Xylol:**—The restrictions relative to this item have been lifted and factors state they are in a position to consider business in this direction. Prices remain firm at the generally quoted range.

**Formaldehyde:**—The government ruling for this item as to prices is still in force. Stocks, however, are reported to be scarce and operators in the resale market are asking from 3c. to 4c. above these figures. Spot lots are difficult to locate and appear only in scattered lots.

**Para Amidophenol:**—Developments for this material have been such that many factors are out of the market owing to their sold up condition. However, available supplies are sufficient for current requirements, and those who have material to offer are still quoting prices at the same levels for both the base material and the H. C. L.

**Dip Oil:**—Manufacturers are in a position to fulfill all requirements of this product and prices are firm.

**Phenol:**—A rather uneasy undertone is prevailing in this market, as there are many manufacturers of this product who were kept busy on government requirements, and the more conservative operators are inclined to await developments before continuing to manufacture. Prices have declined from 2c. to 3c. per pound.

**Benzol:**—There has been a fairly active inquiry for this material and while its production has been plentiful and at the present writing a surplus of stocks is on hand, factors believe this product will again come to the front through its use for automobile propulsion, but this is only an opinion offered by some who are in close touch with the situation. Prices at the moment are firm for material in tank cars and in drums.

**Orthotolidine:**—Offerings of this product are reported to be somewhat more liberal and a rather strong demand is in evidence, but trading is of a routine nature, with no important interest otherwise noted. Quotations generally heard remain at the same firm levels.



General Chemicals

| WHOLESALE PRICES IN NEW YORK MARKET NOV. 22, 1918    |         |                          |
|------------------------------------------------------|---------|--------------------------|
| Acetic anhydride.....                                | lb.     | 1.60 — 1.85              |
| Acetone.....                                         | lb.     | .25 — .251               |
| Acid, acetic, 28 per cent.....                       | cwt.    | 5.96 — 6.11              |
| Acetic, 56 per cent.....                             | cwt.    | 10.76 — 10.87            |
| Acetic, glacial, 99 1/2 per cent., carboys.....      | cwt.    | 19.00 — 19.20            |
| Boric, crystals.....                                 | lb.     | 1.31 — 1.5               |
| Citric, crystals.....                                | lb.     | 1.02 — 1.05              |
| Hydrochloric, C. P.....                              | lb.     | Nominal                  |
| Hydrofluoric, 30 per cent, in barrels.....           | lb.     | .05 — .081               |
| Lactic, 44 per cent.....                             | lb.     | .15 — .16                |
| Lactic, 22 per cent.....                             | lb.     | .06 — .07                |
| Molybdic, C. P.....                                  | lb.     | 6.90 — 7.40              |
| Nitric, 16 deg.....                                  | lb.     | .081 — .10               |
| Nitric, 42 deg.....                                  | lb.     | .40 — .43                |
| Oxalic, crystals.....                                | lb.     | .40 — .43                |
| Phosphoric, 47-50 per cent paste.....                | lb.     | .071 — .10               |
| Phosphoric, ref. 50 per cent.....                    | lb.     | .35 — .40                |
| Picric.....                                          | lb.     | .75 — .85                |
| Pyrogallol, resublimed.....                          | lb.     | 3.25 — 3.50              |
| Sulphuric, 60 deg.....                               | ton     | 16.00 —                  |
| Sulphuric, 64 deg.....                               | ton     | 25.00 —                  |
| Sulphuric, oleum (Fuming), tank cars.....            | ton     | 60.00 — 65.00            |
| Tannic, U. S. P., bulk.....                          | lb.     | 1.40 — 1.95              |
| Tartaric, crystals.....                              | lb.     | 1.70 — 1.75              |
| Uregetic, per lb. of W.....                          | gal.    | 4.91 —                   |
| Alcohol, sugar cane, 188 proof.....                  | gal.    | .911 — .92               |
| Alcohol, wood, 95 per cent.....                      | gal.    | .69 —                    |
| Alcohol, denatured, 180 proof.....                   | lb.     | .06 — .061               |
| Alum, ammonium.....                                  | lb.     | .18 — .19                |
| Alum, chrome ammonium.....                           | lb.     | .20 — .22                |
| Alum, chrome potassium.....                          | lb.     | .091 — .10               |
| Alum, chrome sodium.....                             | lb.     | .02 — .021               |
| Aluminum sulphate, technical.....                    | lb.     | .031 — .04               |
| Aluminum sulphate, iron free.....                    | lb.     | .01 — .09                |
| Ammonia, aqua, 26 deg, carboys.....                  | lb.     | Nominal                  |
| Ammonia, anhydrous.....                              | lb.     | .12 — .13                |
| Ammonium carbonate.....                              | lb.     | (Fixed Price) .071 — .08 |
| Ammonium nitrate.....                                | lb.     | 5.30 — 5.35              |
| Ammonium sulphate domestic.....                      | gal.    | .091 — .13               |
| Arsenic, white.....                                  | ton     | 80.00 — 90.00            |
| Arsenic, red.....                                    | ton     | 65.00 — 67.00            |
| Barium carbonate, 99 per cent.....                   | ton     | 70.00 — 80.00            |
| Barium chloride.....                                 | ton     | .02 — .14                |
| Barium sulphate (Blanc Fixe, Dry).....               | lb.     | .30 — .32                |
| Barium nitrate.....                                  | lb.     | .031 — .04               |
| Barium peroxide, basis 70 per cent.....              | lb.     | .081 — .08               |
| Bleaching powder, 35 per cent chlorine.....          | lb.     | .75 — .75                |
| Borax, crystals, sacks.....                          | ton     | .04 — .05                |
| Bromate, crystals.....                               | lb.     | .15 — .17                |
| Bromine, technical.....                              | lb.     | 1.50 — 1.70              |
| Calcium, acetate, crude.....                         | lb.     | .22 — .23                |
| Calcium, carbide.....                                | lb.     | .09 — .091               |
| Calcium chloride, 70-75 per cent, fused, lump.....   | ton     | .08 — .09                |
| Calcium peroxide.....                                | lb.     | .45 — .45                |
| Calcium phosphate.....                               | lb.     | 1.10 — 1.50              |
| Calcium sulphate, 98-99 per cent.....                | lb.     | .62 — .72                |
| Carbon bisulphide.....                               | lb.     | 4.00 — 4.05              |
| Carbon tetrachloride, drums.....                     | lb.     | .071 —                   |
| Carbonyl chloride (phosgene).....                    | lb.     | 1.65 — 1.65              |
| Caustic potash, 88-92 per cent.....                  | 100 lb. | .021 — .021              |
| Caustic soda, 76 per cent.....                       | lb.     | .30 — .31                |
| Chlorine, liquid.....                                | lb.     | .75 — .78                |
| Cobalt oxide.....                                    | lb.     | .68 — .73                |
| Copperas.....                                        | lb.     | 3.621 — 3.90             |
| Copper carbonate.....                                | lb.     | .161 — .16               |
| Copper cyanide.....                                  | lb.     | .63 — .65                |
| Copper sulphate, 99 per cent, large crystals.....    | lb.     | 4.25 — 4.30              |
| Cumol of tartar, crystals.....                       | lb.     | .13 — .15                |
| Epsom salt, bags, U.S.P.....                         | 100 lb. | .17 — .171               |
| Formaldehyde, 40 per cent.....                       | lb.     | .15 — .18                |
| Glabner's salt.....                                  | lb.     | Nominal                  |
| Iodine, bulk, C. P.....                              | lb.     | 1.12 — 1.15              |
| Iodine, resublimed.....                              | lb.     | .16 — .17                |
| Iron oxide.....                                      | lb.     | 2.05 — 2.05              |
| Lead acetate, white crystals.....                    | lb.     | .17 — .17                |
| Lead arsenate (Paste).....                           | lb.     | .24 — .24                |
| Lead nitrate.....                                    | lb.     | .22 — .24                |
| Litharge, American.....                              | lb.     | 1.40 — 1.65              |
| Lithium carbonate.....                               | lb.     | 18.00 — 20.00            |
| Magnesium carbonate, technical.....                  | lb.     | .12 — .12                |
| Nickel salt, single.....                             | lb.     | .14 — .15                |
| Nickel salt, double.....                             | lb.     | .12 — .13                |
| Phosgene (see Carbonyl chloride).....                | lb.     | 1.10 — 1.50              |
| Phosphorus, red.....                                 | lb.     | 1.00 — 1.15              |
| Phosphorus, yellow.....                              | lb.     | .45 — .46                |
| Potassium bicarbonate.....                           | lb.     | 1.25 — 1.26              |
| Potassium bromide granular.....                      | lb.     | .45 — .46                |
| Potassium carbonate calcined, 85-90 per cent.....    | lb.     | .38 — .40                |
| Potassium chlorate, crystals.....                    | lb.     | .60 — .70                |
| Potassium cyanide, 98-99 per cent.....               | lb.     | 3.75 — 3.80              |
| Potassium iodide.....                                | ton     | 300.00 — 350.00          |
| Potassium murate, 80-85 p. c. basis of 80 p. c.....  | lb.     | .27 — .31                |
| Potassium nitrate.....                               | lb.     | 1.75 — 1.85              |
| Potassium permanganate, U. S. P.....                 | lb.     | 2.30 — 2.50              |
| Potassium persulfate, red.....                       | lb.     | .95 — 1.05               |
| Potassium persulfate, yellow.....                    | lb.     | Nominal                  |
| Potassium sulphate, 90-95 p. c. basis 90 p. c.....   | ton     | .47 — .48                |
| Rochelle salts.....                                  | lb.     | Nominal                  |
| Salammoniac, gray gran.....                          | lb.     | .22 — .24                |
| Salammoniac, white gran.....                         | lb.     | 1.40 — 1.65              |
| Sal soda.....                                        | 100 lb. | 18.00 — 20.00            |
| Salt cake.....                                       | ton     | .12 — .12                |
| Silver cyanide, based on market price of silver..... | oz.     | .631 — .64               |
| Silver nitrate.....                                  | 100 lb. | 2.35 — 2.60              |
| Soda ash, 58 per cent, light, nat (bags).....        | 100 lb. | .60 — 3.75               |
| Soda ash, 58 per cent, dense, flat.....              | 100 lb. | Nominal                  |
| Sodium acetate.....                                  | lb.     | .04 — .041               |
| Sodium bicarbonate, domestic.....                    | lb.     | .24 — .241               |
| Sodium bicarbonate, English.....                     | lb.     | .014 — .221              |
| Sodium bisulfate.....                                | lb.     | .12 — .14                |
| Sodium bisulfite, powder.....                        | lb.     | .25 — .31                |
| Sodium chloride.....                                 | lb.     | .30 — .35                |
| Sodium chromate.....                                 | lb.     | .17 — .18                |
| Sodium fluoride.....                                 | lb.     | .17 — .18                |
| Sodium fluoborate, commercial.....                   | lb.     | .17 — .18                |

|                                             |         |               |
|---------------------------------------------|---------|---------------|
| Sodium hyposulphite.....                    | lb.     | 2.80 — 3.00   |
| Sodium molybdate, per lb. of Mo.....        | lb.     | 2.50 — 5.00   |
| Sodium nitrate, 95 per cent.....            | 100 lb. | 4.75 — 5.00   |
| Sodium nitrite.....                         | lb.     | .35 — .45     |
| Sodium peroxide.....                        | lb.     | .35 — .45     |
| Sodium phosphate.....                       | lb.     | .04 — .041    |
| Sodium prussiate, yellow.....               | lb.     | .03 — .40     |
| Sodium silicate, liquid (60 deg.).....      | lb.     | .03 — .04     |
| Sodium sulphide, 30 per cent, crystals..... | lb.     | .06 — .061    |
| Sodium sulphide, 60 per cent, fused.....    | 100 lb. | .10 — .101    |
| Sodium sulphate.....                        | lb.     | .03 — .06     |
| Strontium nitrate.....                      | lb.     | .25 — .30     |
| Sulphur chloride, drums.....                | lb.     | .071 — .09    |
| Sulphur dioxide, liquid, in cylinders.....  | lb.     | .15 — .16     |
| Sulphur, flowers, sublimed.....             | 100 lb. | 4.75 — 4.50   |
| Sulphur, roll.....                          | 100 lb. | 3.70 — 3.85   |
| Sulphur, crude.....                         | ton     | 65.00 — 70.00 |
| Tin bichloride, 50 deg.....                 | lb.     | .28 — .29     |
| Tin oxide.....                              | lb.     | Nominal       |
| Zinc carbonate.....                         | lb.     | .18 — .20     |
| Zinc chloride.....                          | lb.     | .15 — .151    |
| Zinc cyanide.....                           | lb.     | Nominal       |
| Zinc dust, 350 mesh.....                    | lb.     | .131 — .14    |
| Zinc oxide, American process XX.....        | lb.     | .12 — .14     |
| Zinc sulphate.....                          | lb.     | .041 — .061   |

Coal Tar Products (Crude)

|                                             |      |                    |
|---------------------------------------------|------|--------------------|
| Benzol, pure, water white.....              | gal. | .22 — .27          |
| Benzol, 90 per cent.....                    | gal. | .25 —              |
| Toluol, in tank cars.....                   | gal. | (Fixed Price) 1.50 |
| Toluol, for non-military use, in drums..... | gal. | (Fixed Price) 1.55 |
| Xylol, pure, water white.....               | gal. | .17 — .18          |
| Solvent naphtha, water white.....           | gal. | .18 — .25          |
| Solvent naphtha, crude, heavy.....          | gal. | .12 — .15          |
| Cresote oil, 25 per cent.....               | gal. | .25 — .25          |
| Dip oil, 20 per cent.....                   | gal. | .30 — .32          |
| Pitch, various grades.....                  | ton  | 8.00 — 20.00       |
| Carbolic acid, crude, 95-97 per cent.....   | lb.  | 1.05 — 1.10        |
| Carbolic acid, crude, 50 per cent.....      | lb.  | .60 — .65          |
| Carbolic acid, crude, 25 per cent.....      | lb.  | .35 — .38          |
| Cresol, U. S. P.....                        | lb.  | .19 — .20          |

Intermediates, Etc.

|                                   |     |               |
|-----------------------------------|-----|---------------|
| Alpha naphthol, crude.....        | lb. | 1.00 — 1.10   |
| Alpha naphthol, refined.....      | lb. | 1.50 — 1.60   |
| Alpha naphthylamine.....          | lb. | .55 — .60     |
| Aniline oil, drums extra.....     | lb. | .28 — .30     |
| Aniline salts.....                | lb. | .45 —         |
| Anthracene, 60 per cent.....      | lb. | Nominal       |
| Benzaldehyde (f.f.c.).....        | lb. | 4.25 — 4.50   |
| Benzidine, base.....              | lb. | 1.75 — 1.85   |
| Benzidine, sulphate.....          | lb. | 1.40 — 1.45   |
| Benzic acid, U. S. P.....         | lb. | 3.00 — 3.10   |
| Benzate of Soda, U. S. P.....     | lb. | 2.90 — 3.00   |
| Beta naphthol chloride.....       | lb. | 4.50 — 2.50   |
| Beta naphthol, sublimed.....      | lb. | 10.00 — 12.00 |
| Beta naphthylamine, sublimed..... | lb. | .75 — .85     |
| Dichlorobenzol.....               | lb. | 2.65 — .20    |
| Diethylaniline.....               | lb. | 4.00 — 4.50   |
| Dinitrobenzol.....                | lb. | .36 — .38     |
| Dinitrochlorobenzol.....          | lb. | .40 — .45     |
| Dinitrodichlorobenzol.....        | lb. | .55 — .60     |
| Dinitrotoluidine.....             | lb. | .65 — .75     |
| Dinitrophenol.....                | lb. | .45 — .50     |
| Dimethylaniline.....              | lb. | .75 — .75     |
| Diphenylamine.....                | lb. | 1.00 — 1.10   |
| H-acid.....                       | lb. | 3.25 — 3.50   |
| Metaphenylenediamine.....         | lb. | 1.85 — 2.05   |
| Monochlorobenzol.....             | lb. | .15 — .201    |
| Naphthalene, flake.....           | lb. | .09 — .09     |
| Naphthalene, balls.....           | lb. | .11 — .121    |
| Naphthionic acid, crude.....      | lb. | 1.00 — 1.30   |
| Naphthylamine-sulphonic acid..... | lb. | 1.00 — 1.10   |
| Nitro naphthalene.....            | lb. | .45 — .50     |
| Nitro toluol.....                 | lb. | .55 — .60     |
| Ortho-amidophenol.....            | lb. | 6.50 — 7.00   |
| Ortho-dichlor-benzol.....         | lb. | .15 — .20     |
| Ortho-toluidine.....              | lb. | 1.00 — 1.10   |
| Ortho-nitro-toluidine.....        | lb. | .75 — .85     |
| Para-amidophenol, base.....       | lb. | 4.50 — 5.00   |
| Para-amidophenol, H. C. L.....    | lb. | 4.25 — 5.00   |
| Para-dichlor-benzol.....          | lb. | .15 — .20     |
| Paranitraniline.....              | lb. | .75 — 1.85    |
| Para-nitro-toluidine.....         | lb. | 1.00 — 1.60   |
| Paraphenylenediamine.....         | lb. | 4.00 — 4.50   |
| Para-toluidine.....               | lb. | 2.25 — 2.50   |
| Phthalic acid anhydride.....      | lb. | 4.25 — 5.00   |
| Phenol, U. S. P.....              | lb. | .44 — .44     |
| Resorcin, technical.....          | lb. | 4.50 — 5.00   |
| Resorcin, pure.....               | lb. | 7.00 — 8.00   |
| Salicylic acid.....               | lb. | 1.50 — 2.00   |
| Sulphanilic acid, crude.....      | lb. | .31 — .33     |
| Toluidine.....                    | lb. | 2.50 — 3.00   |
| Toluidine-mixture.....            | lb. | .85 — .90     |

Petroleum Oils

Crude (at the Wells)

|                            |      |             |
|----------------------------|------|-------------|
| Pennsylvania.....          | bbl. | 4.00 —      |
| Corning, Ohio.....         | bbl. | 2.85 —      |
| Somerset, Ky.....          | bbl. | 6.60 —      |
| Waco, Ohio.....            | bbl. | 2.68 —      |
| Indiana.....               | bbl. | 2.28 —      |
| Illinois.....              | bbl. | 2.25 —      |
| Oklahoma and Kansas.....   | bbl. | 2.25 —      |
| Caldo, La., light.....     | bbl. | 2.25 —      |
| Corianna, Tex., light..... | bbl. | 2.25 —      |
| California.....            | bbl. | 1.57 —      |
| Cal Coast.....             | bbl. | 1.35 —      |
| Mexico.....                | bbl. | 1.90 —      |
| Fuel Oil                   |      |             |
| New York.....              | gal. | .15 —       |
| Philadelphia.....          | gal. | .071 — .151 |
| Baltimore.....             | gal. | .071 — .10  |
| Pittsburgh.....            | bbl. | 1.85 — 2.35 |
| Texas.....                 | bbl. | 1.65 —      |
| Los Angeles.....           | bbl. | 1.65 —      |

## Gasoline (Wholesale)

|                      |      |    |    |
|----------------------|------|----|----|
| New York, motor      | gal. | 24 | —  |
| Gas machine          | gal. | 41 | —  |
| 72-76 degrees        | gal. | 33 | 39 |
| 72-77 degrees        | gal. | 32 | 37 |
| 67-70 degrees        | gal. | 30 | 36 |
| Pittsburgh, motor    | gal. | 25 | —  |
| Chicago, motor       | gal. | 22 | 23 |
| Oklahoma, motor      | gal. | 21 | —  |
| San Francisco, motor | gal. | 20 | —  |

## Paraffine Waxes

|                              |     |    |    |
|------------------------------|-----|----|----|
| Crude, 103 to 105 deg. m.pt. | lb. | 08 | 09 |
| Crude, 118 to 120 deg. m.pt. | lb. | 09 | 10 |
| Crude, 124 to 126 deg. m.pt. | lb. | 10 | —  |
| Refined, 120 deg. m.pt.      | lb. | 13 | —  |
| Refined, 128 deg. m.pt.      | lb. | 14 | —  |
| Refined, 135 deg. m.pt.      | lb. | 16 | 16 |
| Orokerite, brown             | lb. | 75 | 80 |
| Orokerite, green             | lb. | 85 | 90 |

## Lubricants

|                                              |      |    |    |
|----------------------------------------------|------|----|----|
| Black, reduced, 29 gravity, 25-30 cold test. | gal. | 24 | 25 |
| Cylinder, light                              | gal. | 45 | 50 |
| Cylinder, dark                               | gal. | 39 | 43 |
| Paraffine, high viscosity                    | gal. | 40 | 41 |
| Paraffine, 0.903 sp. gr.                     | gal. | 36 | 38 |
| Paraffine, 0.885 sp. gr.                     | gal. | 26 | 28 |

## Flotation Oils

(Prices at New York unless otherwise stated)

|                                                                   |      |    |    |
|-------------------------------------------------------------------|------|----|----|
| Pine oil, crude, f. o. b. Florida                                 | gal. | 44 | —  |
| Pine oil, steam-distilled, sp. gr. 0.925-0.940                    | gal. | 58 | 60 |
| Pine oil, destructively distilled                                 | gal. | 58 | 60 |
| Pine-tar oil, sp. gr. 1.021-1.035                                 | gal. | 38 | —  |
| Pine-tar oil, double refined, sp. gr. 0.965-0.990                 | gal. | 42 | —  |
| Pine-tar oil, ref., light, sp. gr. 0.950, tank cars, f.o.b. works | gal. | 37 | —  |
| Pine-tar oil, ref., heavy, sp. gr. 1.025, tank cars, f.o.b. works | gal. | 28 | —  |
| Pine-tar oil, ref., thin, sp. gr. 1.060-1.080                     | gal. | 32 | —  |
| Turpentine, crude, sp. gr. 0.870-0.900                            | gal. | 45 | —  |
| Hardwood oil, f.o.b. Michigan, sp. gr. 0.960-0.990                | gal. | 23 | —  |
| Hardwood oil, f.o.b. Michigan, sp. gr. 1.06-1.08                  | gal. | 23 | —  |
| Wood creosote, ref., f.o.b. Florida                               | gal. | 31 | —  |

## Naval Stores

|                                          |         |       |       |
|------------------------------------------|---------|-------|-------|
| Rosin A-E barrel                         | 280 lb. | 16.60 | 16.80 |
| Rosin F-I                                | 280 lb. | 16.75 | 17.10 |
| Rosin K-N                                | 280 lb. | 17.65 | 18.10 |
| Rosin WG-W                               | 280 lb. | 18.10 | 18.50 |
| Spirits of turpentine                    | gal.    | 85    | 87    |
| Wood turpentine, steam distilled         | gal.    | 62    | 65    |
| Wood turpentine, destructively distilled | gal.    | 58    | —     |
| Pitch                                    | 200 lb. | 8.00  | 13.50 |
| Tar, kiln dried                          | 280 lb. | 14.00 | 14.50 |
| Retort tar                               | gal.    | 80    | —     |
| Rosin oil, first run                     | gal.    | 88    | —     |
| Second run                               | gal.    | 83    | —     |
| Third run                                | gal.    | 88    | —     |
| Fourth run                               | gal.    | 98    | —     |

## Vegetable Oils

|                          |      |      |      |
|--------------------------|------|------|------|
| Castor oil               | lb.  | 34   | 38   |
| China wood oil           | lb.  | 24   | 28   |
| Cocanut oil              | lb.  | 16   | 22   |
| Corn oil                 | lb.  | 18   | —    |
| Cottonseed oil, crude    | lb.  | 20   | 22   |
| Linseed oil, raw, cars   | gal. | 1.81 | 1.86 |
| Olive oil                | gal. | 4.25 | 4.50 |
| Peanut oil, crude        | lb.  | 18   | 22   |
| Soya bean oil, Manchuria | lb.  | 17   | 18   |

## Glues

|                            |      |      |      |
|----------------------------|------|------|------|
| Extra white                | lb.  | 36   | 45   |
| Cabinet                    | lb.  | 31   | 40   |
| Brown foot stock           | lb.  | 18   | 22   |
| Fish glue, 50-gal. barrels | gal. | 1.00 | 1.80 |

## Miscellaneous Materials

|                                    |         |         |       |
|------------------------------------|---------|---------|-------|
| Barytes, flatted, white, foreign   | ton     | Nominal | —     |
| Barytes, flatted, white, domestic  | ton     | 33.00   | 36.00 |
| Beeswax, white, pure               | lb.     | 63      | 65    |
| Beeswax, unbleached                | lb.     | 43      | 48    |
| Blanc fixe                         | lb.     | 05      | —     |
| Casein                             | lb.     | 07      | 30    |
| Ceylon graphite                    | lb.     | 171     | 25    |
| Clay, light, precipitated, English | ton     | 04      | 06    |
| China clay, imported, lump         | ton     | 20.00   | 40.00 |
| China clay, domestic, lump         | ton     | 15.00   | 22.50 |
| Feldspar                           | ton     | 8.00    | 12.00 |
| Fluorspar, gravel, f.o.b. mines    | ton     | 28.00   | 40.00 |
| Fluorspar, washed, powdered        | ton     | 90.00   | —     |
| Fuller's earth, powdered           | 100 lb. | 1.50    | 2.00  |
| Japan wax                          | lb.     | 26      | 27    |
| Mexican graphite                   | ton     | 60.00   | 75.00 |
| Madagascar graphite                | ton     | 10      | 15    |
| Orange shellac                     | lb.     | 72      | 80    |
| Pumice stone                       | lb.     | 04      | 08    |
| Red lead, dry, carloads            | 100 lb. | 11      | 11    |
| Sonpetone                          | ton     | 15.00   | 25.00 |
| Stearic acid, 120 deg. m.pt.       | ton     | 13      | 14    |
| Stearic acid, 140 deg. m.pt.       | ton     | 18      | 19    |
| Talc, American, white              | ton     | 20.00   | 40.00 |
| White lead, dry                    | lb.     | 09      | 10    |

## Refractories, Etc.

(F.O.B. Works)

|                                    |          |        |        |
|------------------------------------|----------|--------|--------|
| Chrome brick                       | net ton  | 175.00 | —      |
| Chrome cement                      | net ton  | 75.00  | —      |
| Clay brick, first quality fireclay | per 1000 | 50.00  | 55.00  |
| Clay brick, second quality         | per 1000 | 35.00  | 40.00  |
| Magnetite, raw                     | ton      | 30.00  | 35.00  |
| Magnetite, calcined, powdered      | ton      | 50.00  | 65.00  |
| Magnetite, dead burned             | net ton  | 50.00  | 60.00  |
| Magnesia brick, 9x4x2              | net ton  | 110.00 | 125.00 |
| Silica brick                       | per 1000 | 50.00  | 60.00  |

## Ferrous Alloys

|                                                                             |     |        |        |
|-----------------------------------------------------------------------------|-----|--------|--------|
| Ferrocobaltitanium, 15-18 per cent, carloads, f. o. b. Niagara Falls, N. Y. | ton | 200.00 | 250.00 |
| Ferrocobalt                                                                 | lb. | 15.00  | 30.00  |
| Ferrocromium, per lb. of Co.                                                | lb. | 250.00 | 40.00  |
| Ferromanganese, domestic, 70 per cent basis                                 | ton | 250.00 | —      |
| Ferromanganese, English                                                     | ton | 325.00 | —      |
| Spiegelisen (16-18%)                                                        | ton | 75.00  | —      |
| Ferromolybdenum, per lb. of Mo.                                             | lb. | 3.50   | 4.50   |
| Ferrosilicon, 75 per cent, f.o.b. N. Y.                                     | ton | 153.00 | 160.00 |
| Ferrosilicon, 50 per cent, contract                                         | ton | 2.35   | 2.40   |
| Ferrotungsten, 75-85 per cent, f.o.b. Pittsburgh                            | lb. | 7.50   | —      |
| Ferrotungsten, f.o.b. works, per lb. of U.                                  | lb. | 7.50   | —      |
| Ferrovanadium, f.o.b. works                                                 | lb. | —      | —      |

## Ores and Semi-finished Products

|                                                       |      |       |        |
|-------------------------------------------------------|------|-------|--------|
| Chrome ore, 45 per cent minimum, f.o.b. Cal. per unit | ton  | 1.50  | 1.55   |
| Chrome ore, 43 per cent and over, New York, per unit  | ton  | 1.40  | —      |
| Coke                                                  | ton  | 6.00  | 7.00   |
| Manganese ore, 48 per cent and over, per unit         | ton  | 1.20  | —      |
| Manganese ore, chemical                               | ton  | 80.00 | 100.00 |
| Niobylene, per lb. of Mo.                             | lb.  | 1.25  | 1.50   |
| Tungsten, Scheelite, per unit of WO <sub>3</sub>      | ton  | 25.50 | —      |
| Tungsten, Wolframite, per unit of WO <sub>3</sub>     | ton  | 23.00 | —      |
| Uranium oxide, 96%                                    | lb.  | 3.25  | 3.60   |
| Vanadium pentoxide, 99%                               | lb.  | 10.50 | —      |
| Pyrites, foreign                                      | unit | 17    | —      |
| Pyrites, domestic                                     | unit | 28    | 30     |

## Plant Supplies

## BUILDING MATERIALS

|                                         |         |        |        |
|-----------------------------------------|---------|--------|--------|
| Common clay bricks                      | M       | 13.00  | 14.00  |
| Hollow tile, 4 x 12 x 12                | M       | 60.00  | —      |
| Hollow tile, 12 x 12 x 12               | M       | 170.00 | —      |
| Lime                                    | ton     | 16.50  | —      |
| Portland cement                         | bbbl.   | 2.50   | —      |
| Single glass (82-lb.), 10 x 26-16 x 24  | ton     | 21.00  | 27.00  |
| Double glass (164 lb.), 10 x 26-16 x 29 | ton     | 31.00  | 39.00  |
| Yellow pine lumber                      | M       | 39.00  | 45.00  |
| Fir lumber                              | M       | 38.00  | 53.00  |
| Hemlock                                 | M       | 24.50  | 40.00  |
| Tarred felt (4-lb. sq.)                 | ton     | 68.00  | —      |
| Roofing pitch                           | ton     | 27.00  | —      |
| Asphalt roofing (35-55-lb. sq.)         | ton     | 1.60   | 2.45   |
| Slate surfaced asphalt shingles         | sq.     | 5.25   | 5.50   |
| Corrugated galvanized iron              | ton     | 109.00 | 127.00 |
| Putty                                   | 100 lb. | 6.25   | —      |
| Red oxide (Epte. Coppars)               | 100 lb. | 15.00  | 20.00  |
| Native red oxide                        | 100 lb. | 3.25   | 8.00   |
| Red metallic paint                      | 100 lb. | 1.20   | 1.50   |
| White lead in oil                       | 100 lb. | 11.84  | 14.00  |
| Red lead in oil                         | 100 lb. | 12.28  | 14.50  |
| Zinc oxide (dry)                        | 100 lb. | 13.00  | 14.50  |
| Zinc oxide—leaded                       | 100 lb. | 9.00   | 10.00  |
| Yellow ochre                            | 100 lb. | 1.50   | 10.00  |
| Ultra marine blue                       | 100 lb. | 14.00  | 50.00  |
| Prussian blue                           | 100 lb. | 135.00 | 150.00 |
| Chrome green                            | 100 lb. | 40.00  | 70.00  |
| Paris green                             | 100 lb. | 43.00  | 49.00  |
| Mineral black                           | 100 lb. | 12.00  | 2.25   |
| Powdered bone black                     | 100 lb. | 5.50   | 12.00  |
| Lampblack                               | 100 lb. | 15.00  | 45.00  |
| Gae carbon                              | 100 lb. | 16.00  | 25.00  |
| Mexican petroleum pitch                 | 100 lb. | 1.00   | 2.00   |
| Gillette                                | 100 lb. | 2.00   | 2.50   |
| Coal tar pitch                          | 100 lb. | 6.00   | 1.25   |

## STRUCTURAL IRON

|                                   |     |        |        |
|-----------------------------------|-----|--------|--------|
| Blue annealed sheet iron          | ton | 84.00  | 89.00  |
| Black sheet iron                  | ton | 96.00  | 104.00 |
| Galvanized iron                   | ton | 105.00 | 135.00 |
| Tern plate, 8-lb. coating         | ton | 150.00 | —      |
| Tern plate, 15-lb. coating        | ton | 177.50 | —      |
| Tern plate, 25-lb. coating        | ton | 200.00 | —      |
| Tern plate, 40-lb. coating        | ton | 240.00 | —      |
| Tin plate, prime                  | ton | 155.00 | —      |
| Tank plates                       | ton | 65.00  | 65.00  |
| Beams, channels, angles, T's, Z's | ton | 60.00  | 70.00  |
| Rivets                            | ton | 88.00  | 92.00  |
| Steel pipe, 1 to 3-inch           | ton | 81.00  | —      |
| Bar iron and steel                | ton | 60.00  | 70.00  |
| Chain (1 inch proof coil)         | ton | 150.00 | —      |
| Nails, bolts, nuts, washers       | ton | 300.00 | 80.00  |
| Tool steels, special alloy        | ton | 300.00 | 500.00 |
| Bessemer pig iron                 | ton | 36.60  | —      |
| Bessemer steel                    | ton | 47.50  | —      |
| No. 2 foundry                     | ton | 37.90  | —      |
| Steel billets (4 x 4)             | ton | 47.50  | —      |

## POWER HOUSE SUPPLIES

|                               |     |      |     |
|-------------------------------|-----|------|-----|
| Steam packing, rubber duck    | lb. | 99   | 110 |
| Asbestos, high pressure       | lb. | 1.76 | —   |
| Asbestos, wired               | lb. | 1.30 | —   |
| Asbestos, graphited braid     | lb. | 1.21 | —   |
| Asbestos, wick                | lb. | 75   | —   |
| Rubber, sheet                 | lb. | 66   | —   |
| Cup grease                    | lb. | 07   | —   |
| Transmission grease           | lb. | 07   | —   |
| Asic grease                   | lb. | 04   | —   |
| Gear grease                   | lb. | 04   | —   |
| Cotton waste                  | lb. | 08   | 11  |
| Hose, underwriters, 2 1/2 in. | ft. | 75   | —   |
| Hose, air, 1 in.              | ft. | 50   | 60  |

# INDUSTRIAL

## Financial, Construction and Manufacturers' News

### Construction and Operation

#### Arizona

**CONGRESS JUNCTION**—The Octaves Mines Co. will build a 200-ton cold reduction plant.

**GLOBE**—J. F. Mayer, City Clerk, will receive bids until Dec. 5, for building sanitary sewers and sewage disposal plant. Work includes two imhoff tanks, two sludge beds, one chlorinator house, etc. Benham Engineering Co., Colcord Bldg., Oklahoma, City, engineer.

**OATMAN**—The Arizona Mossback Mines Co. will build a 250-ton crushing and cyaniding mill. Estimated cost, \$250,000.

#### Arkansas

**ANDERSON**—The Everton Mining & Development Co. will build a 300-ton washing plant.

**BATESVILLE**—The Reeves Mines will install machinery for a 300-ton washing plant.

#### California

**ATASCADERO**—E. C. Lewis will build a large dehydrating plant here, also several smaller plants at various points in San Luis Obispo County.

**LOS ANGELES**—The New Ellen Potash & Chemical Co., Van Nuys Bldg., will build a castor oil mill, including three-story concrete building. F. L. Stitt, architect, Van Nuys Bldg., preparing plans.

#### Colorado

**BRIGHTON**—The Loveland Natural Food Co. will build a dehydration plant here.

**GREELEY**—The Loveland Natural Food Co. will build a dehydration plant here.

**LONGMONT**—The Loveland Natural Food Co. will build a dehydration plant here.

**LOVELAND**—The Loveland Natural Food Co. will build a dehydration plant here.

#### Connecticut

**HARTFORD**—The Hartford City Gas Light Co., 561 Main St., has awarded the contract for the construction of extensive alterations to its building, to J. H. Grozier Co., 17 Van Dyke Ave. Project includes the erection of a laboratory, offices, etc.

#### District of Columbia

**WASHINGTON**—The Department of Commerce will receive bids until Dec. 4 for the construction of a fishery products laboratory at 6th and B Sts. Address Commissioner of Fisheries.

**WASHINGTON**—The Bureau of Yards & Docks, Navy Department, will build a laboratory building at the Naval Hospital. Estimated cost, \$14,000. Noted Nov. 30.

#### Florida

**FORT MYERS**—The American Fish Products Co. has awarded the contract for the construction of a two-story, 50 x 100 ft. and eight 50 ft. buildings, and will install dehydrating, canning, processing and fertilizer machines. G. S. Stone, manager.

**TAMPA**—The Florida Glass Co. will build a new plant. Estimated cost, \$150,000. E. J. Early, Orlando, president.

#### Illinois

**CHICAGO**—The American Steel & Machine Co., Mansfield, will build a two-story 36 x 72 ft. laboratory. Estimated cost, \$60,000. O. H. Raeder, 20 West Jackson Blvd., architect.

**CHICAGO**—The Barrett Co., 2300 Sacramento St., will improve its plant for the manufacture of coal tar products. Estimated cost, \$20,000.

**CHICAGO**—The Chicago, Smelting & Refining Co., 1325 West 51st St., will remodel the plant purchased from the Hills, Benedict Linsend Oil Co., Loomis St., and will remodel same for its own use.

**CHICAGO**—The Wisconsin Steel Co., 106th St. and Torrance Ave., will build a two-story factory for the manufacture of by-products of coke. Estimated cost, \$65,000.

#### Kentucky

**LOUISVILLE**—The Clay Chemical Co., 1402 Lincoln Bank Bldg., will install a charcoal plant, to include plant for evaporating salt. R. E. Gordon, president.

#### Maryland

**HAGERSTOWN**—The Pangborn Corp. will build a two-story, 40 x 70 ft. laboratory and sand house. Estimated cost, \$5000. W. L. Midekauff, 565 Washington St., superintendent.

**HAGERSTOWN**—The Water Board will enlarge its filtration beds at Bridgeport pumping plant to secure improved facilities for treating water from Antietam Creek. J. McPherson Scott, president.

**INDIAN HEAD**—The Bureau of Yards and Docks, Navy Department, Washington, D. C., has awarded the contract for the construction of a nitrate plant, to the DeKemp Construction Co., 161 Nesbit St., Union Hill, N. J. Estimated cost, \$180,000.

#### Michigan

**GRAND RAPIDS**—The Construction Division of the War Department, Washington, D. C., has awarded the contract for the construction of a picric acid plant to the Owens & Ames Kimball Co. Estimated cost, \$1,000,000.

**GRAND RAPIDS**—The War Department, Washington, D. C., has appropriated \$1,500,000 for the construction of a sulphuric acid plant to be located here.

**HAMTRAMCK**—The Michigan Smelting & Refining Co. will build a two-story, 110 x 140 ft. addition to its plant. Estimated cost, \$100,000.

**PORT HURON**—The Port Huron Sulphite Pulp & Paper Co. will build an addition to its plant.

#### Minnesota

**CALUMET**—The Inter-State Iron Co. will build a two-unit iron ore washing plant having a daily capacity of 1000 tons.

**DULUTH**—The Minnesota Steel Co., Gary St., will build a steel plant. Estimated cost, \$150,000. G. L. Price, vice-president.

**IRONTON**—The Millie Laas Mine has awarded the contract for building a new shop and laboratory to A. G. Gionet.

#### Missouri

**ST. LOUIS**—The St. Louis Surfactant & Paint Co., Arlington St. and Terminal Belt Line, will build an addition to its plant.

#### Montana

**PHILIPSBURG**—The Beaver Mining Co. will build a new manganese mill. Estimated cost, \$25,000.

#### New Jersey

**CRANFORD**—C. E. Kaltenbach, 55 Eglew St., Newark, will build a chemical laboratory here.

**NEWARK**—The Rubber & Celluloid Products Co., 56 Ferry St., has awarded the contract for reconstructing its two-story, 40 x 400 ft. factory, which was recently destroyed by fire, to the American Concrete Steel Co., 31 Clinton St.

**ORANGE**—The Radium Luminous Material Corp., Aiden St., will build a one-story research laboratory addition. R. R. Rowland, superintendent.

#### New York

**BUFFALO**—The Buffalo Paper Furnace Co., Hamburg St., will build an addition to its plant.

**BUFFALO**—G. Elias & Bros., Inc., 965 Elk St., will build a gas product plant.

**BUFFALO**—The National Aniline & Chemical Co., Edgewood Arsenal, will build an addition to its plant here. W. T. Miller, secretary.

**LOCKPORT**—The Isoo Chemical Co. will build an addition to its plant. Estimated cost, \$5000. Evan C. Spelden, vice-president, in charge.

**NEWBURGH**—The G. Washington Coffee Refining Co., 147 41st St., Brooklyn, has awarded the contract for the construction of a coffee refining plant on Mill and William Sts., to the Austin Co., 217 Broadway, New York City.

**NEW YORK**—The Metal Delineating Co., 3 South William St., will rebuild its factory, recently destroyed by fire. Plans call for four two-story, 200 x 400 ft. buildings.

**NEW YORK**—Milliken Brothers, Woolworth Building, has purchased the plant of the James H. Young Stone Co., 136th St. and East River, also the adjoining property, and will build a one-story, 50 x 100 ft. galvanizing plant. Estimated cost, \$25,000. J. E. Jennings, vice-president.

**NIAGARA FALLS**—The Electro Metallurgical Co., Union St., will build an addition to its plant for the manufacture of ferro-alloys. Estimated cost, \$14,000.

**NIAGARA FALLS**—The Republic Carbon Co., Sugar St. and New York Central R. R., has awarded the contract for the construction of a plant consisting of four buildings, to the Lackawanna Bridge Co., Bell and Abby Sts.

**POUGHKEEPSIE**—The Palatine Aniline & Chemical Co., North Water St., will build an addition to its plant. Estimated cost, \$40,000. C. O. Tertwilliger, president.

#### Ohio

**RAVENNA**—The Oak Rubber Co., South Prospect St., will build a three-story addition to its plant on Chestnut St.

#### Oklahoma

**CARDIN**—The Burnham Mining Co. will build a 250-ton mill. E. Van Drevett, superintendent.

#### Pennsylvania

**BELLEFONTE**—The American Lime & Stone Co. will build a new dehydrating plant. Estimated cost, \$400,000. A. C. Morris, president.

**BETHLEHEM**—The Air Reduction Co., 177 Pacific Ave., Jersey City, N. J., has awarded the contract for the construction of a plant here, to James Mitchell, Inc., 76 Montgomery St., Jersey City, N. J. Estimated cost, \$50,000.

**CLARENDON**—The Tiona Refining Co. will build an addition to its oil plant. Estimated cost, \$500,000. R. W. Lavery, 120 Penn. Ave., East Warren, superintendent.

**OAKMONT**—The Edgewater Steel Co., Edgewater Station and Allegheny Valley R. R., has awarded the contract for the construction of a one-story, 160 x 125 ft. factory, to the Austin Co., 16112 Euclid Ave., Cleveland, Ohio. Estimated cost, \$60,000.

**WEST BRIDGEWATER**—The Chippewa Oil Co., Beaver, will build a refinery on Market St. to include pipe line, etc. Total estimated cost, \$60,000.

#### Rhode Island

**PROVIDENCE**—The Providence Dyeing, Bleaching & Calendering Co., 52 Valley St., has awarded the contract for the construction of a two-story, 27 x 50 ft. bleachery in addition to its existing building, to H. E. Mathewson, 97 Peace St. Estimated cost, \$7500.

#### Tennessee

**KINGPORT**—The city has awarded the contract for the installation of a filtration plant to the Pittsburgh Filter Manufacturing Co., Fort Pitt, Pittsburgh, Penn. Estimated cost, \$50,000.

#### Texas

**HOUSTON**—The city will build a sewage disposal plant. Estimated cost, \$75,000. E. E. Sands, city engineer.

**PORT NECHES**—The Magnolia Petroleum Co., Galveston, will build an oil refinery on a site recently purchased here.

#### Utah

**CASTLEGATE**—The Utah Fuel Co. will build a water purification plant to include rapid sand filter, storage tanks, pumping plant and pipe line. Estimated cost, \$10,000.





# CHEMICAL & METALLURGICAL ENGINEERING

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### Stability of First

#### Importance for Industry

IN a recent address before the American Dyestuffs Manufacturers' Association, DR. F. W. TAUSSIG, Chairman of the United States Tariff Commission, laid down the important proposition: "Stability is of the first importance for any industry and at all times. Business can accommodate itself to almost any conditions, provided they be steadily maintained. This is true as regards prices and wages, banking and monetary systems, income taxes and taxes on business, and, not least, as regards tariff duties. It is quite as important, probably more important, that duties should be settled as that they should be high or low, well or ill adjusted. It is imperative to know on what basis business calculations may be made.

"Not only is this the case with regard to an individual business or a particular industry; it is true also as regards the prosperity of the country at large. Vacillation and uncertainty in tariff policy are probably more harmful than any extreme of high duties or of low duties. The good results which are obtainable through a protective system endure only if such a system is maintained consistently for a considerable period,—if time is given for the development of domestic industries, for growth under assured conditions, for the introduction of improved methods through long-continued experiment. And similarly, the good results which are obtainable under a policy of free trade are dependent upon its maintenance over a long period. They can come only through steady competition among foreign producers and domestic distributors, and the adjustment of export trade as well as of import trade to larger volume. A consistent policy followed for a considerable stretch of time is in either case essential for the attainment of the desired results.

"Let us now look at the situation which is to be expected in the immediate future in this country, and look at it frankly and openly. Let us not disguise the facts by vague generalities, by pleasant words, by rose-colored optimism. The truth, plainly stated, is that the outlook for stability is poor. Indeed, the prospects are of the slightest for anything in the nature of a settlement of the tariff. Consider the obvious facts of the political situation. We are at the beginning of the short session which closes the 65th Congress. In the 66th Congress, which will be in session from March 4, 1919, to March 4, 1921, there will be no unification of control and hence there can be no unification of policy. One party will have a majority in the House of Representatives; the Administration itself is of another party; the Senate will be very evenly divided. Not only this, but the traditional division of opinion and policy on the tariff



will not only be maintained, but is likely to be accentuated. The controversy on the protective policy will go on, and will be conducted on party lines. That controversy, it need hardly be said, is not between protection and free trade. The practical issue is one of degree,—whether there shall be high and strong protection all around, or limited and moderated protection. But the cleavage is clear. I will not undertake to say whether a permanent settlement will ever be reached in this country; but it would seem certain that not even such a provisional settlement as comes by the enactment of a general tariff law is within the bounds of probability for the next two or three years."

Clearly it is of primary importance for all American business men to meet the coming situation. The recent conference at Atlantic City, of which there is an account in this issue, and the Chicago meeting next month of the American Institute of Chemical Engineers are to serve as national clearing houses of thought. Stability in business depends on the business men getting together and taking united action.

## That Missing Page

### From the Blue-back Speller

**A**N OLD "blue-back speller" still lingers in the minds of many of us as the staunch craft in which we were launched into this motley world of art and science. In the well-thumbed volume which was ours in those carefree days there was—how vividly we recall it!—a page torn out by some prior owner, probably as the instrument for some boyish class-room prank. Alas, years have passed, and with them the soiled blue-back with its missing page. Yet sometimes when sitting down to write a bit, and that trenchant word which polishes some epigrammatic phrase is laboriously evolved, we are compelled to pause for the spelling of it—should there be an "i" or an "a"? And then flashes suddenly into memory the missing page in the "blue-back," and it is beyond peradventure that this much-needed word once had there its proper place.

During the war hundreds of chemists and metallurgists were engaged in the most varied researches. But far too often they were confronted with a lack of knowledge concerning some very simple phenomenon, which, according to all the laws of common sense, should have been set down in black and white in that other primer which the earnest seekers after truth have written large in technical literature. It is on the missing page!

To be specific: The efficient use of manganese ferro-alloys is a matter of national interest, not only from the standpoint of economy in ferro-manganese but of more dependable metal—say gun-linings to be used overseas. Colonel W. P. BARBA of the Ordnance Department, in discussing the recent paper of Professor HOWE on "The Erosion of Guns," seriously questioned the practice of adding cold lumps of ferro-manganese to steel in the ladle, and pointed out that segregation was to be expected due to failure of the lumps to melt with sufficient rapidity to diffuse through the bath. If a change in steel-works' practice would help to safeguard the lives of our gunners "over there," we should have moved heaven and earth to put it into effect.

Before being able, however, to come to a decision as to the validity of the point raised, certain information of a very simple nature is needed. How long does it

take a piece of cold ferro-manganese the size of a walnut to melt when in contact with molten steel? If it is a matter of only thirty seconds then it would seem that preliminary melting of the ferro-alloy would be unnecessary, in fact undesirable on account of the power cost and the loss of at least some of the manganese. The question of chilling the bath does not seem to enter into the problem, as it obviously does in the case of spiegeleisen additions. If the melting, on the other hand, requires twenty minutes, it is another matter. Once the lump is melted, it would not seem to matter exactly at what part of the ladle it began to diffuse into the steel bath, since, in these circumstances, diffusion is a very rapid process, especially when aided by the strong convection currents existing in the ladle.

Inquiry among metallurgists of our acquaintance did not uncover any substantiated information as to the approximate length of time it takes such a lump of ferro-manganese to melt. Certainly it is a simple matter to determine experimentally. An electric furnace, a plum-bago crucible or two and a couple of hours, and we venture to say that this very important question could be solved. After this is done, it will be possible to discuss the disadvantages of adding cold ferro-manganese in the ladle more intelligently.

This is only an isolated case where technical progress is hampered by a lack of knowledge regarding fundamentals. Before writing any more essays in these fields we need to get out a revised, complete edition of the scientific "blue-back speller."

## The Smith-Howard Bill

### and Industry's Opportunity

**T**HE Smith-Howard Bill (S-3805 and HR-9686) provides that in each state or territory of the nation there be organized an engineering experiment station in an established university, college or engineering school within its boundaries. The purpose of these stations is to conduct research "in all branches of engineering, manufacturing and the industries, including chemistry, physics, electricity and other sciences." They are also to co-operate with agricultural experiment stations. They are to publish bulletins annually (at least), and these are to give the "results of said researches, investigations and experiments or reports of progress" in relation to the work in hand. The United States Government is to appropriate for each station \$15,000 the first year, \$20,000 the second, \$25,000 the third, \$30,000 the fourth and regularly \$30,000 each year thereafter. The legislature of each state shall designate the institution to engage in such study, subject to the approval of the Secretary of Commerce, who shall indicate lines of inquiry that seem important from a military or industrial standpoint. There is appropriated annually \$25,000 to establish and maintain in the Bureau of Standards a Department of College Research which shall keep all records and extend the facilities of the Bureau as far as is practicable. Provision is also made that the sum of money appropriated for research at any station shall not exceed that actually required for efficient and productive work.

The bill is supported by a committee of which President Maclaurin of the Massachusetts Institute of Technology is chairman, and we have received from Dr. W. Whitney of Schenectady an appeal in its favor.



Of course, under defective administration, the working of the proposed law could be resolved into a mere waste of money, but the time has arrived for us to exercise the quality of faith in our government. The party system under which it operates provides that active and even intense criticism be always maintained, and under this the chances are that a Cabinet member who used these funds for political purposes would soon find himself in hot water. The post of research professor in such institutions is not an easy job for a deserving Democrat or a regular Republican, unless he has the equipment both mental and temperamental to prosecute the work. We are not afraid of politics in this measure, and even if it should creep in, we have abundant faith in the instruments of publicity at hand to put an end to it.

Here is an opportunity for the industries of the country to become interested in and to benefit by the progress of science as it relates to each particular field. It will not take the place of individual or industrial research laboratories. We shall always have progressive men in industry who will keep ahead of the game. And the measure provides two greatly needed features: the opportunity to engage the activities of men gifted with the talent for research to their maximum usefulness for the general welfare, and it will drive into the minds of those industrial administrators who still sorely need it the enlightenment that the ways of stuff are not mystic or esoteric or past finding out, and that the mastery of particles unseen is not a hereditary gift, passed on along with secret formulæ or as the endowment of conjuring. Furthermore the co-operation of the Government in such research work with our educational institutions will undoubtedly be of much fundamental value to the curriculum, the student and industry.

### Steel Consumption and Investments

WITH the removal of Government control from iron and steel prices there is in prospect the form, if not the substance, of an open market. It is improbable that prices will decline at once, for the average producer has no incentive to cut. He has contract business on books, and the contract business can be worked out better if the market does not decline, while there is some demand at current prices and there is practically no latent demand that is awaiting a decline in the market to a certain determined level before it will take hold. How long prices will remain at their present level, or substantially that level, cannot of course be determined.

Perhaps there will be a time when iron and steel producers will be criticised for not reducing their prices, on the ground that development work is held back by iron and steel not being available at prices that would encourage buying. Circumstances are such as to develop a distorted view of the economics of the case. The cost of steel is a definite thing, while the cost of consuming steel is an indefinite thing. The one is quoted in market reports, the other is not. One can refer to current reports and see that structural shapes are priced at three cents a pound, and historical records can readily be consulted to show, for instance, that in occasional instances in the past they sold at a cent a

pound or a trifle more, also that the average quoted market price in the ten years before the war was just a trifle over a cent and a half a pound. Thus we have a cent a pound, a cent and a half a pound and three cents a pound, which is all very precise and concise, and also accurate, which is another matter, for accuracy is not a necessary attendant of precision and conciseness.

A large part of the steel made is placed in employment rather than consumed or used up. In other words it is an investment. To put steel into use as an investment always costs some money, and usually it costs a great deal. Now, the cost of steel is a matter of market reports and statistics, all clear and plain, but the cost of putting steel into employment is an altogether indefinite thing. It depends on the costs of various commodities and upon the cost of labor, not merely the hourly or daily rate of wages, but the cost of recruiting labor, the cost of supervising it and the hourly or daily work that is done by the labor in return for the amount paid. There are no market reports on this and no statistics easily consulted and covering all cases, like the market price of standard sizes of structural shapes.

By reason of this condition, the average observer, if he is not careful and conscientious in his habits of thought, is likely to be impressed by the cost of steel and to lose sight very largely of the cost of utilizing steel. To the investor it is all the same thing. The final cost of his investment, compared with what the cost would be six months, two years, five years, later, is all that he considers. The cost of the steel represents one group of items, the cost of all else another and very large group of items.

The average investment usually represents construction work, in which labor is employed. All wage rates have greatly advanced, but in the steel industry the advance in labor cost is a more definite and clear-cut thing than it is in the case of most construction work. The men at blast furnaces and in steel mills have definite duties to perform, and there has been no great variation in their performance. In the main, they simply receive more money per day. With construction work the variation is much greater, for there are two factors, the hourly or daily rate of wages and the amount of performance. The first had advanced, the second declined. There is room for a decrease in construction costs apart from a decrease in the nominal rates of wages paid. As to construction materials apart from steel, some have advanced more than steel, some less. Some present difficulties in securing deliveries apart from the price, and the progress of construction work requires unanimous consent of all the elements entering. All told, the cost of putting steel into employment is an item that has diverged widely from the former normal, and has shown puzzling trends. It is a more difficult item for the prospective investor to appraise, in relation to conditions that might obtain later, in case he delayed making his investment, than is the item of cost of steel. It may easily require much more time to produce a stable outlook for the cost of employing steel than to produce a stable outlook for the steel market itself. The steel industry, therefore, cannot force the situation by attempting to bargain with the investor. He has other and very important matters he must consider besides the cost of his steel.

## Western Chemical and Metallurgical Field

### The Golden Cycle Cyanide Plant

THE GOLDEN Cycle Mill at Colorado City is the sole survivor of the many plants erected outside the Cripple Creek district to treat the gold tellurides from that remarkable camp. Erected originally as a bromination plant in 1902 by the Telluride Reduction Co., it was converted to the cyanide process four years later, and since that time has been successfully combating, by good management and intelligent metallurgy, the decreasing ore tenure and increasing operating costs. Briefly, the present process consists of crushing, roasting, grinding and classification. The sands are leached and the slime agitated and filtered. About twice as much material goes to the sand tanks as to the slime plant.

Mr. A. L. BLOMFIELD, manager, and Mr. M. J. TROTT, assistant superintendent, recently contributed an important paper to the transactions of the American Institute of Mining Engineers, describing their present roasting practice and pointing out how variations in this department have affected the entire subsequent treatment of the ore. It is a matter worthy of note that while few American gold ores require roasting before cyanidation, the Golden Cycle is the largest mill in the world roasting gold ores, treating 361,000 tons of ore in 1917, valued at 7½ million dollars. Edwards roasters are used, which were developed and universally used in West Australia.

High-grade Cripple Creek ores are treated exclusively. As is well known, these are sulpho-tellurides containing practically no lead, copper, zinc, arsenic or antimony. Of recent years the lime content has tended to increase, so that those ores containing more than 2 per cent CaO are bedded separately from those containing less, the latter comprising about two-thirds of the total. It is essential that the crushing produce a minimum of fines, to prevent excessive dusting in the roasters; on the other hand, coarse particles yield their gold well, it being largely carried in veinlets, but they would contain much unroasted sulphides which deoxidize the solutions and consume cyanide. It has been found practicable to produce a dead-roasted calcine, but careful tests demonstrated that for the conditions existing at the Golden Cycle a soluble sulphur content of 0.10 per cent and soluble sulphide content of 0.10 per cent in low-lime ores (0.15 per cent in high-lime ores) will actually produce a lower residue. Chemical consumption and the dissolution time is somewhat higher, but the roasting is

evidently cheaper. Close control of the heats in the Edwards furnaces is maintained by indicating pyrometers, and chemical control is had by quick methods of analysis, especially developed to supplant the wholly unsatisfactory eye-control. At the same time it has been found possible to halve the dusting in the roasters by baffling the exit gases away from the feed drop-holes, revising the location of the side-doors, submerging the discharge and substituting an open for a revolving cooler. The temperatures in the furnaces at present are about the same as when roasting to 0.05 per cent insoluble sulphur; the feed has merely been increased.

The calcine is ground in Chilean mills with cyanide solution. Quantities of calcium sulphate formed in roasting by reaction between CaO and metallic sulphides go into solution here, to be later deposited in pipes, launders, tanks and filters on cooling, and to "set" the sands in leaching tanks. Roasting practice, therefore, maintains the third firebox at a red heat in order to dehydrate the sulphate and render it insoluble. Wherever practicable, pipes are being re-

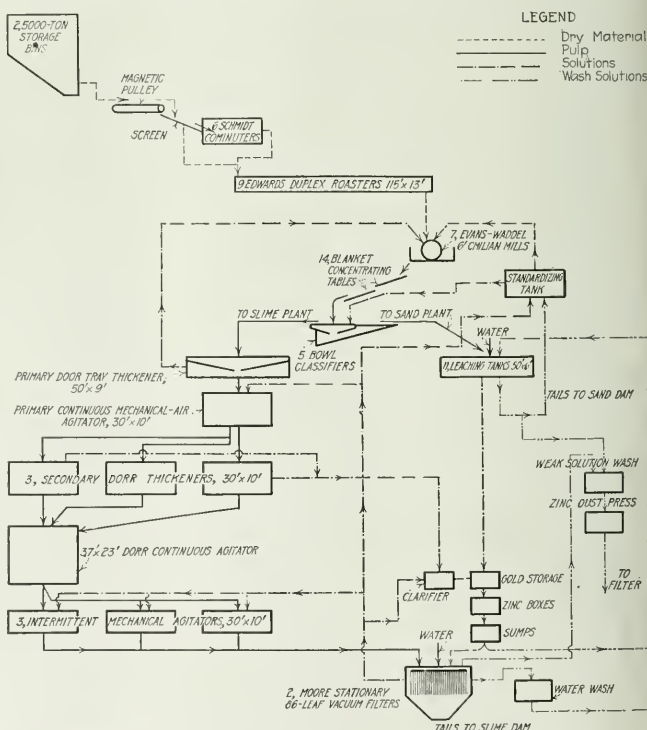


FIG. 1. SKETCH OF FLOW OF PULP AND SOLUTIONS GOLDEN CYCLE MILLS

placed by launders in order to remove the incrustation which forms even at best.

An important feature of the process as employed at both the Golden Cycle and the old Portland Mill is the use of blankets for the recovery of the free gold liberated by roasting, and it is of interest to note that one of the oldest known processes for the recovery of gold plays an important function in the modern cyanide

plant. Extensive investigation has shown that this gold in a partially roasted ore is not readily amenable to either cyanide treatment or direct amalgamation. Blanketing was first introduced by Mr. J. M. Tippet at the Portland Mill in connection with the treatment of chlorination tailing. Each Chilean mill at the Golden Cycle is followed by two blanket concentrating tables, being merely apron-plates covered with a cotton bed-blanket. The cleanup is ground in astra and grinding pan, the tails from the final small astra being blanketed before passing into the main mill-feed, and the final concentrate is amalgamated in a barrel in strong cyanide solution.

Such delicately controlled roasting practice is liable to produce calcine of varying quality, especially just after one of the 5000-ton ore beds has been drained and before the new material is properly adjusted. If some insufficiently-roasted material should get into the system, solution of gold would be retarded by the deoxidizing power of the soluble sulphides, and rich residues would result. Rapid leaching of the sands is a precautionary measure attained by freeing them entirely from colloids and by loading the tanks in a semi-dry condition by conveyor and distributor. Desliming is done in a Dorr Bowl Classifier, consisting essentially of a shallow thickener, 13 ft. in diameter, set immediately above the lower compartment of a duplex drag-classifier. The slime overflowing the bowls will run 90 per cent through 200 mesh, the slime plant requiring a minimum of 88 per cent. Sulphides remaining in the slime are neutralized by immediate aeration in a 30 x 10-ft. mechanical-air continuous agitator, as is shown in the diagram, Fig. 1. In addition to these precautions, it is essential that a quick change of solution be made. On the sands this is done by the wash solution in the classifiers. A shallow, primary tray thickener receives the slime overflow from the bowl-classifier, and is of minimum volume so it may be cleared within half an hour.

### Powered Coal for Igniting D. and L. Roasters

**A**N EXPERIMENTAL apparatus has been devised and used at the Midvale Smelter of the United States Smelting, Refining & Mining Co. for determining whether powdered coal could be substituted successfully for the more valuable fuel oil in igniting various lead-cro mixtures on a Dwight and Lloyd roaster. The results have been so gratifying that a permanent installation is now being installed in their roaster plant to serve all of the six machines now running. The permanent installation will contain a Raymond coal pulverizer, the product of which will be delivered by 4-in. screw conveyors to small steel hoppers at each furnace. The coal will then be burned by an apparatus very similar to that found so successful in the experimental work. It is expected that the results will be fully equal to the present; in fact, with some ore-mixtures coal gives a better cake than oil, since the oil flame apparently fuses the topmost surface, restricting the air-flow necessary for roasting and agglomerating the deeper layers. From 450 to 500 pounds of pulverized coal per day will suffice to operate one roaster, in place of 70 gallons of fuel oil.

As shown in Fig. 1, a small variable-speed motor

is belted to a reduction-gear driving at 30 to 40 rotations per minute a 2-in. worm passing through the bottom of the hopper containing pulverized coal. The coal delivered by the worm drops through a 1-in. pipe into a tee, where it meets a stream of compressed air at from 12 to 20 pounds and is then blown into the burner and ignites. The air receiver hides this part

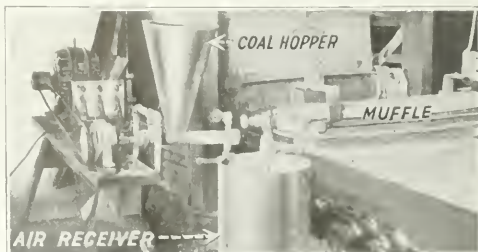


FIG. 1. EXPERIMENTAL POWDERED COAL INSTALLATION

of the apparatus, which is diagrammed in the sketch, Fig. 2. The compressed air is taken from the regular service lines for pneumatic tools (90-lb. pressure) through an adjustable pressure-reducing valve. An air receiver, consisting of an ordinary domestic hot-water tank, is tapped on the line near this point to absorb pulsations in the air supply. The bushings at both

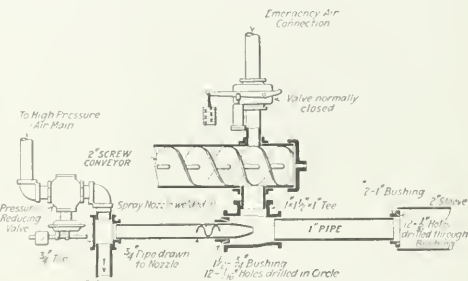


FIG. 2. SKETCH OF PIPING FOR EXPERIMENTAL PULVERIZED-COAL BURNER

mixing chamber and burner are drilled with a number of small holes so that auxiliary air may be drawn in as desirable. A helical screw is fixed in the line just before the mixing tee so that the whirling air supply may expand into a wide spray. In operation the mixture of air and coal is ignited by some burning waste until the muffle becomes hot enough to maintain the flame near the end of the 2-in. pipe sleeve.

This successful innovation was made by Mr. Howard Wright of the roasting department and Mr. William Erickson, engineer, working under the supervision of Mr. E. H. Hamilton, general superintendent.

Vernier Scales for reading decimal parts on graphic charts can readily be made on a tenth basis by applying the edge of a sheet of paper to the coordinates 10 and 4.58 and marking off the tens, and on a hundredth basis by using 100 and 1 as coordinates and marking off the intersections with the 100-lines. This is of use in accurately reading small scale charts.



## Atlantic City Meeting of the War Service Committees

Several Thousand Prominent Business Men Representing Three Hundred and Eighty Industries Hear Addresses on Reconstruction, Discuss and Pass Resolutions—Plan to Expand Scope of the Chamber of Commerce of the United States

THE meeting held under the auspices of the Chamber of Commerce of the United States Dec. 3 to 6 was a memorable occasion, and if we were asked to describe it we should say it was distinctly characterized by sanity, breadth of view and generosity. The plan was excellent, and the details, although rather jumbled at first, were brought into order by the second day. The general meetings held in the great hall of Young's Pier were attended to capacity. It is said that the place will seat 6000 persons comfortably, but there was not even standing room for all those who desired to attend these general meetings.

### ADDRESS OF PRESIDENT WHEELER

The addresses were remarkable contributions to the constructive thought of the day. Mr. Harry A. Wheeler, President of the Chamber of Commerce of the United States, made the first of these on Wednesday and treated more particularly of reconstruction, pointing out certain principles which must be applied if victory is to be secure in the fulfillment of those aims for which our men have fought. He pointed out how diplomacy needs the aid of men of business in its councils, more particularly in the problems of readjustment. Already, he said, whisperers, trouble-breeders and jugglers with words and reputations are turning their eyes to the unsavory diplomacy of the past and are intimating jealousies and jockeyings for position for which there should be no hearing at all among men of good will. He urged a more enlightened diplomacy which shall be free from secrecy and open to the judgment of public opinion.

He proposed an international plan for rationing raw materials so that nations which are not fortunate enough to possess them may be free to develop their science and their arts. He urged a live-and-let-live policy for the whole world. We must make the most of available tonnage and he insisted that if those nations which have the power to contribute to the reconstruction of countries and peoples stricken by the devastation of war do not bear these obligations in mind, then hardships and difficulties will be inordinately prolonged.

On Nov. 23 last he addressed a letter to the President asking if it would not be helpful if American industry should name a committee, informed in the basic industries of the country, to be present in France during the meetings of the Peace Conference and available for counsel in negotiations which bear directly upon commerce and industry. The President replied that frankly he did not know what message to contribute to the Atlantic City meeting, but that we should all take counsel and apply the wisest action to circumstances as they arise.

In its final resolutions the Conference concluded that a body of such competent men of large vision and generous impulses should be present. Other problems con-

sidered were subjects of extended debate at the various group meetings and found expression in the resolutions adopted at the final session.

### THE SECRETARY OF COMMERCE

On Wednesday Secretary Redfield made an earnest appeal for the application of science to industry. He gave a brief outline of the extraordinary activities of the Bureau of Standards and extended a cordial welcome to American business men to enter its open portals. He outlined the work of the Department of Commerce in the extension of foreign trade. The agents of the Government engaged in this service, he said, were required to be intimately familiar with the subjects which they are sent abroad to investigate and are required to have an easy reading, writing and speaking knowledge of the language of each country to which they are sent. He hoped that greater appropriations for an increase in the number of these useful agents of trade may become available.

### MR. CHARLES M. SCHWAB

Mr. Charles M. Schwab, Director General of the United States Emergency Fleet Corporation, first got his six or seven thousand auditors into good humor and then proceeded to discuss what he regarded as the most immediate problem before us in matters of reconstruction, which has to do with labor. We are all in the same boat, he declared; time was when capital tried to be the sole ruling factor in affairs, and labor has done the same thing. It cannot succeed. He recalled with no little humor the efforts made by trusts to control prices and profits without much consideration of the consumer, and he painted the consequences in lively colors. In regard to the Fleet Corporation, he said that when he undertook the direction of its affairs, he knew it would succeed if only American labor would back him up, and he was proud to say that American labor had done this very thing. Of course there had been troubles; it is impossible to gather in such a vast army of workers without having some whose vision of the general welfare is blinded by selfishness. But in the main they had been gloriously loyal to their country's call, and he could not put too much emphasis upon that fact. His only reason for leaving the post at the head of the Fleet Corporation was to return to the 170,000 employees under him at Bethlehem and elsewhere to provide for the best pay and the best conditions that may be brought about. He is a firm believer in organization within the works or the corporation and in the maximum of safeguarding every man's rights as well as his life and his liberty.

### PRESIDENT FARRELL OF THE U. S. STEEL CORPORATION

On Dec. 5 Mr. Farrell was unable to get to Atlantic City and his address was read in his absence. It had to do with foreign trade, and he said that it had grown

to such proportions that it was no longer necessary to convince manufacturers to enter it, but that our present task was rather to devise and guide. So devastating, however, has the war been that we cannot expect export trade to flourish unless we provide capital in those countries where we hope that our business may prosper. We must enter into their industrial life, engage in enterprises with them and thus create out of their resources the new wealth from which will come our pay. The advent of women into industry has been so great and so general that he doubted whether there would be as marked a shortage of industrial labor in the near future, even in war-devastated countries, as has been anticipated.

MR. JOHN D. ROCKEFELLER, JR.

Mr. John D. Rockefeller, Jr., spoke at the same meeting as that at which Mr. Farrell's paper was read, taking for his subject "Representation in Industry." He said that Capital, Management, Labor and the Community were the four parties to industry and that each was entitled to representation. Capital is represented by stockholders and is usually regarded as including management, but this is a serious error. The function of management is different and it is represented by technical skill and managerial experience. Labor is represented by the employees, but its contribution, unlike that of capital, is not detachable from the one making it, for it is his physical effort, his strength, his life. The community contributes the maintenance of law and order, the agencies of transportation and communication and many other services of prime importance. And the community consumes the product. Selfishness is not to be tolerated. Whether men work with brain or with brawn they have the same cravings, the same aspirations, the same hatreds and the same capacity for suffering and enjoyment. He insisted that we must organize a new order of things and provide some plan of co-operation which will insure to all concerned adequate representation, an opportunity to earn a fair wage under proper working and living conditions with such restrictions as to hours as will leave time for recreation and the development of the higher things of life as well as time to eat and to sleep.

He outlined a method which he favors which provides for the representation of labor and for appeals from decisions, and he gave a number of instances in which the plan is in successful operation. In conclusion he stated what he called his labor creed, which was included in a short form as the sense of the convention by a resolution unanimously adopted at the final meeting on Friday.

MR. PAUL M. WARBURG

Mr. Warburg, until lately a member of the Federal Reserve Board, made the last address on Friday. He recommended that to enable the United States to take its place as a foremost power in the commercial and financial world and to be fully equipped, the Capital Issues Committee and the War Finance Committee be continued. Government responsibility and influence in industry will tend to elevate business, but it presents the danger, he said, unless carefully guarded in form and scope, of corrupting and debauching the government itself. In the call for the continuation of these com-

mittees he added there is no challenge to England. He is certain England will retain her logical and traditional position as a world center for commerce and finance. Germany's position as an international banker will have to be considered as vacated for some time to come, but England, the United States and soon France as well will become partners rather than competitors; not partners in a close corporation to the exclusion of others, but rather in an establishment wide open to any respectable associate wishing to enter.

#### NINETY SPEECHES

As announced in our previous issues, the three hundred and eighty-odd war committees were grouped into thirty-six sections called related groups, which met in various places on the evening of Dec. 4. At each of these meetings there were addresses and here also resolutions were discussed which were brought in from the War Service Committees or offered from the floor. All resolutions passed were turned over to the corresponding unit of the ten major groups into which the thirty-six were consolidated and which met on the following (Thursday) afternoon at 2:30 and evening at 8 o'clock. Here again addresses were delivered, but our readers will understand why we cannot print these ninety addresses despite their leading importance to the industries involved. With apologies for our shortcomings in this respect we shall add a few notes from the addresses delivered before the committees on chemicals.

#### SECRETARY REDFIELD AGAIN

Chairman Henry Howard of Boston, who presided over the deliberations of Group 26, induced Secretary Redfield to add to his remarks of the same day in the Great Hall. Mr. Redfield's impression of the prospective status of the German chemical industry is that it will be far less favorable than before the war. That the country is evidently pretty well used up was indicated by the sore complaint that arose at the armistice demand for a certain number of locomotives and cars. The purpose was merely to restore the locomotives and cars taken from Belgium and France by the Germans. If the complaint is well founded that the act leaves them without the means of transportation, then the deduction is reasonable that the German railway system is used up as to equipment and that that of French and Belgian origin was used for replacement. He believes that the cost of production in Germany will increase more in proportion than it will here. Returning to the subject of scientific development in this country, he added the note that on the second day of President Wilson's first administration it was agreed between the President and himself that no man in the scientific service of the Government should be removed or appointed for political reasons, and that the agreement has been kept.

MR. W. D. HUNTINGTON

Mr. W. D. Huntington of the Davison Chemical Works, Baltimore, gave some information of the acid industry and its status. In 1914 we produced 4,200,000 tons of sulphuric acid of 50 deg. B. In 1917 this had increased to 8,300,000, and if the war had continued four or five months longer we should have been producing at the rate of 9,600,000 tons annually. The out-

look is that the only part of the country where any congestion of acid may occur will be in the Northeast. The rated capacity of plants outside of those owned by the Government is 6,200,000 tons, and in the South the fertilizer industry will absorb the output of the two great privately owned munition plants that are located there. The Government plants are closing. In the Northeast it may be necessary to reduce production to 70 per cent of capacity for awhile.

The great stocks of nitrate and sulphur at the Government plants should not be thrown upon the market, and he was glad to say that steps are being taken to avoid this very thing. The sulphur, for instance, will be taken in charge by the sulphur companies and distributed by them. The Government is anxious to dispose of stocks in such a manner as to do so to the greatest advantage and with the least hindrance to trade. In the discussion which followed Mr. Charles H. McDowell expressed the opinion that the consumption of acid will be at least 1,000,000 tons more than in 1914 and that an increase of 1,500,000 tons would be a closer guess.

#### MR. A. W. HAWKES

Mr. A. W. Hawkes, Vice President of the General Chemical Company, followed with the belief that increased consumption of sulphuric acid will take up the slack. The best way, in his opinion, is to play a waiting game for the next ninety days. In the meantime, he said, antiquated plants are being discontinued, and others, with the stress of extreme production removed, are being put into better operating condition.

#### DR. J. MERRITT MATTHEWS

Dr. J. Merritt Matthews read a paper on "Safeguarding the Dye Industry," in which he described the proposed British method of prohibiting the import of dyes made within the kingdom and requiring that a license be obtained from a special commission for every importation of foreign colors. The commission is to have very great power, for it is assumed that it will also grant licenses for importations to supply needs in excess of that which is made at home. Despite the many objections that may be raised against it, Dr. Matthews believes it to be the best method available to control the situation. If the licensing system should not be adopted, he recommended that both intermediates and dyes have equal protection to avoid the establishment of foreign houses to put through the last and simplest processes in making dyes from materials almost but not quite finished, which under the present law they could import under one-half the tax which the finished product pays.

#### DR. W. H. NICHOLS

Major Group 7 included all the junior groups related to it, and it met Thursday afternoon and evening under the chairmanship of Mr. Horace Bowker. The afternoon speaker was Dr. William H. Nichols, President of the American Chemical Society and Chairman of the Board of the General Chemical Co.

His address was an appeal to prevent the dye industry, which has taken such an effort to establish, to lapse, because it is so closely bound up with the development of chemistry and more particularly with chemical research and it contributes so much to that kind of pre-

paredness for war which is the best defense against it. He called special attention to the fact that the industry has not yet matured with us. To prove it he took the figures lately issued by the Tariff Commission giving the number of concerns engaged in making dyes and intermediates and the number of men engaged, and he divided the total men employed into the tonnage. Then he made a similar computation of the latest available



DR. WILLIAM H. NICHOLS

German data, and the showing was very unfavorable to the present American dye industry compared with that which formerly obtained in Germany. In other words, taking the entire industry of the country and including all engaged in it, the yields or finished product per man employed are still inadequate to meet German competition. This should involve no reflection upon American chemists. The war problem was to produce the things needed at any cost, and in many cases this was done. Now in organic syntheses there are often a number of ways to make a thing and it takes time and patience and chemical scholarship to develop the best method and then to nurse it along to maximum efficiency. This very development is in process now wherever sound chemical control is coupled with scholarly research, but results are not to be reached over night. Dr. Nichols had no definite measures to propose as to the specific means of conserving the industry, but he expressed his firm conviction that if our chemists have a fair chance for a reasonable time, without outside interference, we can lead the world in making dyes. He held to this without being frightened over the fact that the Swiss works are all unified, that the German works have joined in a Cartel, and that in England, France, Italy and Japan direct action has been taken by various steps such as prohibition of imports or guarantees of dividends to assure the maintenance of the industry in those countries.

At the evening session Mr. Charles H. McDowell of the Chemicals Division of the War Industries Board gave an interesting and illuminating outline of the problems which the Committee had to meet. He expressed the opinion that very cheap producer gas power



had been developed in Germany and he went into detail in regard to the nitrate situation from the beginning. Toluene production has increased from 500,000 gallons a year in 1914 to the rate of 24,000,000 gallons a year now. The alkali industry has increased in great measure, but he believed that the closing down of the Government electrolytic plants would avoid the production of excess alkali. The War Board, he said, tried to be constructive in its destruction and found many substitutes for materials that were required, a considerable number of which have entered into permanent use. The oxygen output has increased 1400 per cent since 1914 and 92 per cent of the whole is distilled from liquid air. He gave a long list of contributions made by the Mellon Institute of Industrial Research at Pittsburgh to the War Board and he urged upon industry the increase of technically trained men in its personnel. In regard to potash he doubted if Germany will be able to produce as cheaply as before the war, and he regarded as fair possibilities the outlook for about 30,000 tons from blast furnaces and 50,000 tons from the cement industry (on a  $K_2O$  basis) in this country under normal conditions. The cost at Searles Lake cannot be determined until larger quantities are produced, and the Georgia shales, containing 6 to 8 per cent of  $K_2O$ , he believed also to be a promising source of supply. In conclusion he noted the greatly increased team work throughout chemical industry as a result of the common experience of its many leaders who have given their time to the War Industries Board.

#### FEW FREAK RESOLUTIONS OFFERED

It stands to reason that in such a vast assemblage of men, all sorts and kinds of resolutions should be proposed. They always are, and they were this time. Sometimes the myopics (who constitute the short-sighted brotherhood) would line up at the back of the room at group meetings and vote through resolutions that had no place there,—and sometimes they failed in the attempt. There were some rather amusing incidents in this connection. The laundry owners, for instance, undertook to have it declared to be in the interest of the general welfare that articles washed for the retail trade should not be deliverable until four days after the pick-up. The motion was lost. The surgical instrument makers, on the other hand, firm in the faith that all things should work together for their good, managed to put through a demand at a group meeting that the United States Government should not dispose of any surgical instruments now in its possession until they become obsolete, "in order to be at all times prepared for war." There were, however, surprisingly few efforts of this sort, and excellent provision was made for them. After matters had been threshed over first at the related group meetings and again at the major group meetings, all resolutions were sent to the Clearance Committee, which worked all night, referred all piffle and unbaked ideas back to the Executive Committee of the Chamber of Commerce and by their supremely able drafting of consolidated ideas, presented those which follow in substance at the general meeting which closed the conference on Friday.

All of their proposals were adopted with nearly complete unanimity. Lack of space makes certain abridgements necessary.

### The Resolutions Adopted

*Cancellation of War Contracts:*—It is in the public interest that all war orders placed by any contracting agency of the Government and accepted in good faith, whether formally and regularly executed or not, should, upon cancellation by such contracting agency, be promptly and equitably adjusted and satisfied as if every formality had been observed, and when so adjusted the amount ascertained to be due by the Government should be promptly paid to the end that these funds may be utilized by the industries of the country to speed their transition from a war to a peace basis.

If it should be ascertained that legislation is necessary or desirable to accomplish this end, Congress should forthwith enact such legislation.

Officials dealing with questions of adjustment on account of war orders must necessarily be familiar with all the conditions affecting the order. It will greatly promote expedition and the interests of both the Government and private enterprise for the officials who made the contracts to remain in the Government service to participate in the readjustments.

*Surplus Government Supplies:*—Under date of Nov. 29, 1918, the Secretary of War issued a public statement, i.e., "To prevent too violent dislocation of industry from the standpoint of both employee and employer, accumulation by the War Department of either raw material or finished product will be distributed when and where liquidation of such supplies will least interfere with the return of industry to a normal condition." Such action would seem to insure the stability of the industries affected, which fully appreciate this liberal position.

Therefore the War Service Committee of American Industries hereby tender to the War Department their services for their respective industries for the purpose of advising with and assisting the War Department in the disposition of such materials.

*Removal of Restrictions of Industry:*—It is in the public interest that all war regulations of industry should be revoked and all war restrictions on industry should be removed as speedily as practicable, save such industries as are engaged in the production, preparation or distribution of foods, feeds and fuel, and such last named group of industries should be freed from war regulations and restrictions as early as consistent with the welfare of this nation and of the Allies.

*Pivotal Industries:*—Conditions brought upon us by the European war at its beginning, as well as our national necessities after we entered the war, made it of the highest importance that a number of industries should at once be developed in the United States. Large investments, both of capital and skill, have since been placed in these enterprises. Upon the production of some of them, relatively small in themselves, the continuation of some of our largest industries has depended. Some of the recently developed industries have national importance in fields much broader than the markets of their products; for they may serve, for example, to promote scientific research, which will add to national efficiency, resources and wealth in many distinct ways.

It becomes essential, therefore, that the Government should at once proceed to ascertain the industries which have been developed during the European war and ascertain those the maintenance of which are indispensable for the safety of our industrial structure and our military establishment.

When these pivotal industries have been ascertained, means suitable in view of their nature and situations should at once be provided for their encouragement and preservation.

*Industrial Co-operation:*—The war has demonstrated that through industrial co-operation great economies may be achieved, waste eliminated and efficiency increased. The nation should not forget, but rather should capitalize these lessons by adapting effective war practices to peace conditions through permitting reasonable co-operation between units of industry under appropriate Federal supervision. It is in the public interest that reasonable trade agreements

should be entered into, but the failure of the Government to either clearly define the dividing line between those agreements which are and those who are not in unreasonable restraint of commerce, or to provide an agency to speak for it on application of those proposing to enter into such agreement, in effect restricts wholesome co-operation and deprives both industry and the general public of its benefits. The conditions incident to the period of readjustment render it imperative that all obstacles to reasonable co-operation be immediately removed through appropriate legislation.

**Federal Trade Commission.**—The Federal Trade Commission was advocated by the President and was created as an agency to make the administrations of our trust legislation explicit and intelligible, and to provide "the advice, the definite guidance and information" which business enterprises require. The normal importance of the Commission's task is now tremendously increased by the imperative need for whole-hearted and systematic co-operation between the Government and industry especially during the readjustment period and suggests the desirability of the two existing vacancies in the Commission's membership being promptly filled with able men of broad business experience and clear vision prepared to assist actively in discharging these tasks along constructive lines.

**Industrial Relations.**—The Convention heartily indorses in letter and spirit the principles of the industrial creed so clearly and forcibly stated in the paper read to it Thursday morning by Mr. John D. Rockefeller, Jr., and urges upon all units of industry where they may not now be employed the application of such principles.

Without approving or rejecting his particular plan or machinery, the principles advanced by Mr. Rockefeller are as follows:

1. Labor and capital are partners, not enemies; their interests are common interests, not opposed, and neither can attain the fullest measure of prosperity at the expense of the other, but only in association with the other.

2. The purpose of industry is quite as much to advance social well-being as material well-being and in the pursuit of that purpose the interests of the community should be carefully considered, the well-being of the employees as respects living and working conditions should be fully guarded, management should be adequately recognized and capital should be justly compensated, and failure in any of these particulars means loss to all.

3. Every man is entitled to an opportunity to earn a living, to fair wages, to reasonable hours of work and proper working conditions, to a decent home, to the opportunity to play, to learn, to worship, and to love, as well as to toil, and the responsibility rests as heavily upon industry as upon government or society to see that these conditions and opportunities prevail.

4. Industry, efficiency and initiative, wherever found, should be encouraged and adequately rewarded, and indolence, indifference and restriction of production should be discountenanced.

5. The provision of adequate means for uncovering grievances and promptly adjusting them is of fundamental importance to the successful conduct of industry.

6. The most potent measure in bringing about industrial harmony and prosperity is adequate representation of the parties in interest; existing forms of representation should be carefully studied and availed of in so far as they may be found to have merit and be adaptable to the peculiar conditions in the various industries.

7. The application of right principles never fails to affect right relations; the letter killeth and the spirit maketh alive; forms are wholly secondary, while attitude and spirit are all important, and only as the parties in industry are animated by the spirit of fair play, justice to all and brotherhood will any plans which they may mutually work out succeed.

8. That man renders the greatest social service who so co-operates in the organization of industry as to afford to the largest number of men the greatest opportunity for self-development and the enjoyment by every man of those benefits which his own work adds to the wealth of civilization.

**Relocation of Labor.**—The conversion of the industry of

the country from a peace basis to a war basis involved a general and important dislocation of labor. This movement was gradual. The end of the war involves a much more rapid change in industry; while there will be a great demand for labor to meet the foreign and domestic requirements, there may be for a time in special places a temporary condition of unemployment.

In the new relations of industry to labor we conceive it to be incumbent upon the community affected promptly to meet such conditions.

**Public Works.**—The development of public works of every sort, as recommended by the President, should promptly be resumed, in order that opportunities of employment may be created for unskilled labor.

**Taxation.**—The cessation of hostilities brings to business interests a feeling of deep concern in the matter of taxation. The problems of readjustment are made more difficult through inequalities in the present law.

We believe, therefore, that in the consideration of amendments to the present act, or the passage of new revenue legislation, the Congress should give most careful consideration to the views expressed by organizations of commerce and industry. Ability to pay, inventory values and proper reserves, together with careful survey of the amount of revenue required under the new conditions, are matters of vital importance to business interests of the nation during this readjustment period.

**Inventories.**—We urge that Congress should give careful consideration to the grave menace now facing all industry due to the fact that both raw materials and finished goods are carried in full measure to meet the extraordinary requirements of the Government and of the people, and that in large part the stocks have been acquired at abnormal cost and are therefore carried into inventories at inflated values, thereby showing apparent profits which have not been realized, and which probably will never be fully realized. These are largely bookkeeping or "paper" profits, and should not be used as a basis for taxation.

We therefore recommend that any tax law shall provide that during present conditions the taxpayer shall be allowed to make a deduction from his apparent profit by way of a reserve for subsequent shrinkage in merchandise values.

We believe that the interests of the Government can be protected against abuse of this privilege by the fixing of a maximum percentage of deduction to be allowed and by the use of proper methods of inspection and appraisal.

**Water Powers.**—Industrial activity is dependent upon the available supply of power. A bill which would affect the development of hydro-electric power upon waterways and lands which are subject to Federal jurisdiction is now before a committee of conference between the two houses of Congress. It is important in the public interest that Federal legislation on this subject should be enacted without further delay. We accordingly urge that the conference committee arrive at an acceptable form of legislation in season for enactment at this session of Congress.

**European Commission.**—The business men of the United States, having devoted their energies and resources toward the winning of the war, regardless of sacrifices or burdens, in support of the principles for which this country fought, appreciate the necessity of continuance of unremitting effort in order that the world may be restored to normal conditions as quickly as possible and the blessings of peace brought to all peoples.

In the accomplishment of these results the highest efficiency of the great commercial and industrial powers of our own country and that of the Allied nations will be developed only through co-operative effort and common counsel.

In order, therefore, to contribute to the fullest toward the prompt solution of the problem presented, the Chamber of Commerce of the United States is requested to enlist the co-operation of national bodies devoted to the extension and promotion of American commerce and particularly foreign trade, in the appointment of a commission representative of American business, which shall proceed without delay to Europe and establish machinery for the following purposes:

1. To study at first hand the reconstruction needs of European countries in conjunction with business men of these nations in order to advise the business men of the



United States as to how they may be most helpful in meeting the necessities of Europe and caring for the interests of American industry and commerce.

2. To be available to the peace delegates of the United States for any needed information which they may be able to present or for any other aid which may be given by the business men of the United States through the medium of such a commission.

The Chamber of Commerce of the United States also is requested to appoint members of the Commission to represent the business men of the United States at the forthcoming meeting of the Permanent Committees of the International Congress of Chambers of Commerce.

**Markets for Foreign Trade.**—We strongly urge upon our Government the vital necessity of encouraging and developing our foreign trade through all appropriate means possible, in order that the production of industry may afford employment to wage earners and prosperity to the nation.

**South American Relations.**—It has long been the policy of this nation to cultivate relations of close sympathy with the nations of the Western Hemisphere as expressed in the Monroe Doctrine. We believe that these relations should be supplemented and strengthened by a vigorous development of our commercial and financial associations with our neighbors of North and South America.

The Government's control of shipping should be brought to the accomplishment of this purpose as soon as it is consistent with other urgent needs, and the work of the Pan-American Union should be continued and broadened in scope.

**Property Rights in Mexico.**—By provisions in a constitution adopted while much of the country was engaged in civil strife, and through subsequent legislation, Mexican authorities have threatened rights acquired by Americans in good faith, especially in minerals, including petroleum. Against threatened confiscation the American Government made formal protests. The attitude taken by the American Government is heartily commended as in accordance with obvious justice.

**Education for Foreign Commerce.**—In the larger opportunities which are to be opened to American business men to play a part in the international commerce of the world the need will be felt for more men who are trained to a knowledge and understanding of the language, the business methods and the habits of thought of foreign lands. Complete success can only come to those who succeed in putting themselves into full accord and sympathy with the peoples with whom they are to deal.

We urge upon our industrialists that they take steps to provide opportunities to young men to obtain an education in the practices of overseas commerce and finance and in the practical use of foreign languages.

We call the attention of the various departments of Government and to educators to the importance of this matter and ask that special efforts be made to supplement the valuable work already done and to open up every facility to the furtherance of a successful prosecution of this educational work.

**Forest Products Laboratories.**—The Forest Products Laboratories, of the United States Forest Service, have rendered valuable service through scientific investigation of the physical properties of American woods and their adaptability for structural, industrial and ornamental usage. It is of great importance to American industry that the Government should extend and adequately maintain the work of the Forest Products Laboratories.

**Cost Accounting.**—It is the sense of this Convention that uniform cost accounting should be adopted by industries.

Other resolutions favor the return of railways to their owners under proper conditions, oppose Government operation of telephones, telegraphs and cables, favor the development of the merchant marine, the amplification of port facilities, the proper study by Congress of public utilities, the generous provision of raw materials to our Allies for reconstruction, the extension of scope of the Council and Executive Committee of the Chamber of Commerce, and resolutions of appreciation of the work of the speakers, the committees and the Associated Business Papers for their daily newspaper.

## Institute of Chemical Engineers Chicago, Jan. 15-18

THE secretary of the Institute, Dr. John C. Olsen, Polytechnic Institute, Brooklyn, N. Y., announces this tentative program for the winter meeting:

"What Is Going to Be Done by the Tariff Commission on the Question Relative to the Chemical Industry?" Dr. Grinnell Jones, U. S. Tariff Commission, Washington, D. C.

"United States Dye Industry," Dr. L. J. Matos and Dr. L. C. Jones, National Aniline Co., New York.

"Reinforced Concrete Tanks for Storing Ammoniacal Liquors," Dr. F. W. Frerichs, St. Louis, Mo.

"Reconstruction Aspects of Some Chemical Industries in the United States," Dr. Edward Gudeman, Chicago, Ill.

"Some Wild Engineering," Dr. David Wesson, Montclair, N. J.

Excursions will be made to the plants of the Corn Products Co., Argo, Ill., Lindsay Light Co. and Underwriters Laboratories in Chicago, Standard Oil Co., Whiting, Ind., and the Newport Hydrocarbon Co., Milwaukee, Wis.

The following letter has been sent to the chemical manufacturers of the United States:

"GENTLEMEN:—On Jan. 15 to 18, 1919, the annual meeting of the American Institute of Chemical Engineers will take place in Chicago. The chemical manufacturers of the United States are invited to send representatives to discuss the subject of the maintenance and preservation of our chemical industries.

"There are some who believe that a high protective tariff is all that is necessary to preserve the chemical industries. There are others who believe that only the newer chemical industries should be fostered, but it is the belief of your committee that the chemical industry of the United States must be carefully assisted not through any one particular means but through various methods which your committee briefly outlines.

"It is impossible to forecast the future, but if Germany fosters or otherwise subsidizes its chemical industries by means of specially low freight rates and transportation facilities, or if other countries pursue such a policy, the American chemical industries will be at a great disadvantage as far as export trade is concerned.

"Of course it is not to be presumed that the chemical industries will ask governmental assistance in those things which the chemical industries are competent to take care of themselves. This phase should also be presented.

"In 1919 a large amount of shipping will leave these ports filled with the necessities of life, such as food, agricultural implements and metals, and in preference to coming back in ballast, they may take freight at such low rates, and Germany may be willing to sell the materials it has on hand at such ruinous figures in order to obtain real money, that for a time paralysis of our industries may ensue.

"Another condition that always confronts manufacturers is unnecessary and undue competition, and our laws prevent co-operation excepting in cases of export. These are only a few of the conditions which must be manfully met and solved, and at the January meeting of the Institute the fullest discussion is invited, and the aid of our congress will be invoked.

"Will you be good enough to signify to the Secretary whether you will send a representative to attend this meeting. Respectfully submitted,

L. H. Baekeland,  
Maximilian Toch,

"G. W. THOMPSON,  
"President."

Chairman, Committee of Maintenance and Protection of Our Chemical Industries.



# Aluminium-Manufacturing Processes Used in Europe\*

Historical Review of Researches and Commercial Developments—Refining of Raw Materials—Description of Bauxites Used and Processes for Obtaining Pure Alumina—Manufacture, Consumption and Requirements for Electrodes—Information About Operating

By O. NISSEN

IN 1811 Sir Humphry Davy produced an alloy of iron and aluminium by using an iron bar as the cathode. Thirteen years afterward Oersted is said to have produced the metal by heating aluminium chloride with potassium amalgam. Wohler in 1827 succeeded in producing it simply by reducing aluminium chloride with metallic potassium. As the materials were not pure and on account of the volatility of the chloride, the reaction was carried out at a low temperature. Up to 1845 Wohler had been able to produce only small particles of the metal, about the size of a pinhead. In 1854 Bunsen obtained aluminium for the first time by the electrolysis of aluminium-sodium chlorides, but electrolytic processes could not be of any practical importance at that time on account of the non-existence of large sources of electric current. Henry Sainte-Claire Deville developed the chemical reduction process after 1854 and with the help of Napoleon III a factory was built at Javelle. A few bars of aluminium were exhibited at the Paris Exposition in 1855 which attracted a great deal of attention. Deville conducted aluminium chloride vapor over incandescent potassium and had purer materials than Wohler. In place of potassium, Deville also used the cheaper sodium, and later he worked with aluminium-sodium chloride, which is less hygroscopic and more stable than aluminium chloride.

When in 1854 cryolite, the double fluoride of aluminium and sodium, was brought for the first time from Greenland to Europe, Dr. H. Percy produced aluminium from it by reduction with metallic sodium. At the same time and independently, H. Rose made the same experiment, and in 1855 he was the first one to produce aluminium by electrolysis of cryolite, when he was endeavoring to electroplate other metals with aluminium. Rose also used synthetic cryolite, and he reported: "This synthetic cryolite, as well as the natural, gives aluminium when reduced with sodium. Aluminium is also produced under the influence of the electric current, but not when alumina is dissolved in aluminium fluoride alone." Rose determined that cryolite, which is easy to pulverize and not hygroscopic or volatile, gave better results than aluminium chlorides or their combinations with chlorides of the alkali metals. Bunsen and Deville experimented in 1856 on the electrolysis of molten cryolite, but could not obtain the required electric current.

Chemical plants were built at Paris and Salindre. Th. Bell established a plant using Deville's process at Washington-on-Tyne in England. He also experimented with the electrolytic process. These plants were worked for about thirty years without material changes, but later magnesium was used as the reducing agent instead of sodium.

M. Heroult in 1887 constructed a practical electric reduction furnace for the commercial manufacture of aluminium by electrolysis, using alumina dissolved in molten cryolite. The fundamental principles of the furnace were chiefly those suggested thirty years previously by Bunsen and the electrolysis of the alumina

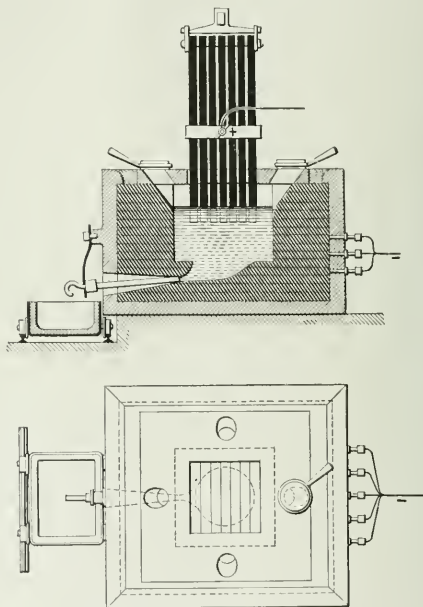


FIG. 1. HEROULT'S FURNACE

dissolved in cryolite was well known to Deville and others. The only novel feature, as was pointed out, was that the current was used both for the reduction of the aluminium and for heating the furnace, while before it had been the practice to heat the furnace externally by means of combustion. Bradley obtained a patent in America on just this idea.

Heroult's furnace, Fig. 1, consisted of an iron casing lined with carbon bricks. The current was introduced through a bundle of carbon anodes which could be raised or lowered by means of a chain. The total cross-section of the anode was 30 x 30 sq.cm. and the length 1.2 m. The bath occupied a space of 50 x 30 sq.cm., the inside height being 60 cm. The electric current varied from 3000 to 4000 amperes and was supplied by a generator at from 13 to 14 volts. The current passed through the molten cryolite, in which the alumina was dissolved, down to the casing which comprised the cathode. The alumina was decomposed and the aluminium settling at

\*Translated from *Teknisk Tidsskrift*, August, 1917.

the bottom was drawn off, while the oxygen liberated, in contact with the anode, combined with the carbon to form carbon monoxide, which is immediately burned, forming carbon dioxide on contact with the air. The carbon anodes are in this manner gradually used up. The raw materials were supplied to the furnace through openings in the fireproof cover. Heroult produced aluminium in large quantities and it is unquestionably to him that the credit belongs for having developed the electrolytic method so that it became of practical importance in France.

In Calypso, Minet experimented with lowering the temperature of the bath. He used aluminium fluoride with 60 per cent sodium chloride and also cryolite with 50 to 80 per cent salt. Minet's furnace, Fig. 2, has both the anode and cathode suspended in the bath; this is, however, not good practice. It reminds one of Bunsen's experimental furnace, Fig. 3. Hall experimented in America on adding to the cryolite, which was mixed with alumina, potassium, sodium, lithium, chloride and also calcium fluoride.

Following the Bucherer patented process, it is said that the Aluminium Industries Co. in Neuhausen carried out successful experiments on electrolyzing aluminium sulphide,  $Al_2S_3$ . The furnace voltage was very low—5 volts—and the metal pure. The sulphur was

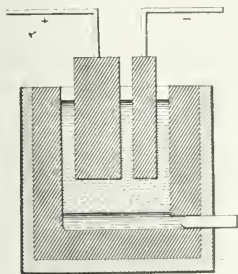


FIG. 2. MINET'S FURNACE

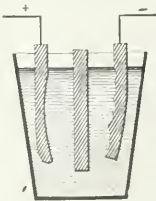


FIG. 3. BUNSEN'S FURNACE

condensed and used again for producing new aluminium sulphide. The production of the aluminium sulphide by heating alumina, carbon and sulphur requires so much heating that the process was too expensive. The process now generally used in Europe for manufacturing aluminium has been developed directly from Heroult's furnace, although the type now in use has been much enlarged and improved. Heroult died shortly before the war with Germany broke out.

The great future that was entertained in the minds of many for aluminium and its production is reflected in the fact that during the '90s a large number of patents were taken out, the majority being more or less valueless. According to some of these patents, aluminium should be produced by electrolysis of water solutions. This could, of course, not lead to any commercial results, as aluminium in *status nascenti* is hydrolyzed by water. Also, according to others of these patents, aluminium should be produced directly by reduction with carbon in electric arc furnaces or in electric resistance furnaces. However, at the reduction temperature of 2000 deg. C. mostly aluminium carbide was produced. If this problem could be solved and aluminium manufactured in large furnaces of several thousand

kilowatts instead of in the present electrolytic baths of about 150 kilowatts, it would, of course, be of immense value.

Cowles tried in America and at Milton in England to smelt aluminium and carbon in retorts, but the product which he obtained was valueless, as it contained too much carbide. His furnace, Fig. 4, was  $1\frac{1}{2} \times 1\frac{1}{2}$  m. and

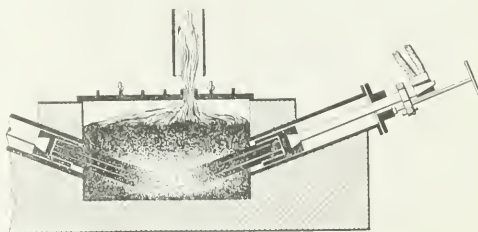


FIG. 4. COWLES' FURNACE

$\frac{1}{2}$  m. high. Cowles did, however, produce aluminium alloys, and avoided thereby the formation of carbide.

Moissan, in an experimental furnace, Fig. 5, obtained aluminium with some carbide content and, besides, carbide and corundum crystals. He heated alumina and carbon in a carbon tube by means of an electric arc. Many chemists have worked with this reaction, but without practical result. To prevent carbide and oxidation formations Ruff and Giuliani suggested vacuum furnaces in which the reaction would take place around 1500 deg. C. Askenasy suggested just the opposite, i. e., pressure furnaces.

#### THE COMMERCIAL PRODUCTION OF ALUMINIUM

Only a few kg. of aluminium were produced during the first years succeeding 1854, and from 1863 to 1878 the yearly production did not exceed 2 kg.; from 1878 to 1888 between 10 and 40 tons were produced. The price was more than 1000 fr. per kg. at the beginning, but due to installation of Deville's and other processes it dropped to 300 and later to 100 fr. It was, however, not until the latter part of the '80s that the price fell to an economical level because the electrolytic plants in-

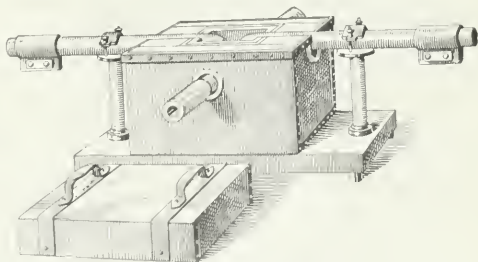


FIG. 5. MOISSAN'S FURNACE

creased the production so that in 1891 it amounted to 333 tons at a price of 4 fr. per kg.

From the diagram, Fig. 6, it is seen how rapidly the production increased. After 1893 the price dropped still more and was in 1900 or 1901 about 1.60 fr. per kg. On account of this drop the International Aluminum Syndicate was formed, the object of which was to en-

deavor to control the market and get better prices. La Société-Electrometallurgique Français des Froges, La Compagnie des Produits Chimiques d'Alais et de la Carmargue, Alluminum Industrie Gesellschaft Neuhausen, Pittsburgh Reduction Co. or the Aluminum Company of America and finally the British Aluminum Co. were the members of this syndicate. The production as well as the consumption of aluminium increased, and the price went up and reached 3.20 fr. per kg. in 1907.

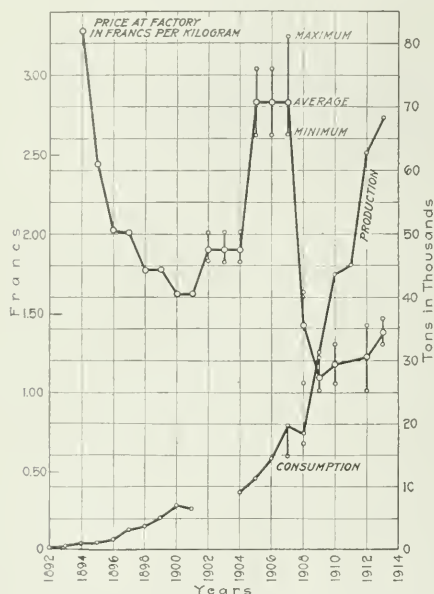


FIG. 6. PRODUCTION AND PRICES

The over-production of the years following and the general business depression caused a violent drop in the price. English firms fought against bankruptcy, many plants were shut down, the syndicate was dissolved and the price dropped to 1 fr. per kg. The price, however, increased before the war to more than 2 fr. and all plants began operation again. A few even enlarged their facilities. A French syndicate was again formed in 1910, and it became international in 1913.

The yearly production before the war was 68,000 tons, divided as follows:

|                                        | Per Cent |
|----------------------------------------|----------|
| United States .....                    | 33       |
| Canada .....                           | 8½       |
| Switzerland, Germany and Austria ..... | 17½      |
| France .....                           | 26½      |
| England .....                          | 11       |
| Norway .....                           | 2½       |
| Italy .....                            | 1½       |

France and Switzerland were the countries that exported most aluminium, the amount for the last years before the war being 7000 to 8000 tons each. Germany, on the other hand, has imported aluminium; the statistics being 16,000 tons in 1912 and 12,500 tons in 1913.

It is difficult to obtain accurate information in regard to the aluminium production during the war. The prices have been abnormally high and a large number of new plants have been built, and contracts entered into for deliveries for several years after the war. Ger-

many and Russia will probably be the chief future consumers in the international market. It is possible that if all the plants which are building or contemplated are put in operation, the production after the war may be doubled, in which case we may figure on a yearly production of around 150,000 tons, divided as follows:

|                                        | Before the War<br>Per Cent<br>of 68,000 | After the War<br>Per Cent<br>of 150,000 |
|----------------------------------------|-----------------------------------------|-----------------------------------------|
| United States and Canada .....         | 41½                                     | 50                                      |
| Switzerland, Germany and Austria ..... | 17½                                     | 13                                      |
| France .....                           | 26½                                     | 13                                      |
| England .....                          | 11                                      | 8                                       |
| Norway .....                           | 2½                                      | 11½                                     |
| Italy .....                            | 1½                                      | 4½                                      |

For Norwegian factories it may be proportioned as follows:

|                  | Tons |
|------------------|------|
| Arendal .....    | 5000 |
| Tysedal .....    | 6000 |
| Vigeland .....   | 2000 |
| Stangfjord ..... | 600  |
| Hoyang .....     | 4000 |

These estimates have recently been made by a French engineer and indicate that France does not expect to keep up the hold it had on the aluminium industry before the war. When, however, the French saw the threatened competition of other countries, they immediately proceeded to build factories of their own in these countries. From a financial standpoint France will, therefore, continue to be the leader in the aluminium industry for some time to come. The French have been able to maintain this position, not only on account of their large bauxite deposits, but mainly due to the fact that they have been the pioneers of both the chemical and later the electrochemical aluminium industry. Not only have they tried to improve the methods of its production, but at the same time they have devoted just as much attention to finding new fields for its utilization. It may be predicted that, next to iron, aluminium will be the most important industrial metal.

These results could never have been obtained if it had not been realized from the beginning that an impure aluminium would have greatly discredited the product, and the problem has therefore all along been one of producing as pure a metal as possible.

#### METHODS OF REFINING RAW MATERIALS— ALUMINA FROM BAUXITE

At present there exists no satisfactory process for purifying metallic aluminium, and the only manner in which a pure product can be obtained is by the use of pure raw materials. This was clearly understood by Deville. The main raw materials for production of aluminium are alumina and carbon electrodes, and the obtaining of these with the required purity will be described in the following:

The alumina is produced by purifying bauxite, the red grade of which contains large amounts of impurities such as iron oxide and silica. According to the Deville-Pechiney process the bauxite is pulverized and mixed with anhydrous sodium carbonate in the ratio of 75 per cent bauxite and 25 per cent soda. The mixture is then heated two to three hours in a reverberatory furnace, whereby sodium aluminate is formed. This is separated from the iron oxide by leaching with warm water. The alumina is then precipitated from the extract solution by passing carbonic acid through the strong liquor, the carbonic acid being obtained from the



reverberatory furnace or lime calcining ovens. The process takes 5 to 6 hours at 70 deg. C. The precipitated alumina is then washed with clean water, filtered and dried and is then ready for the production of aluminium. The carbonated solution is evaporated and the soda recovered.

The Deville-Pechiney process is not economic as far as the fuel consumption is concerned and the Bayer method has superseded it. The operation of this is also somewhat simpler. The red bauxite is pulverized so as to pass through a screen of 5 mm. mesh and is cal-

much of the latter will cause a loss in alumina in that in the soda solution there is formed a non-soluble aluminium-sodium silicate of the approximate formula



In French bauxite of 61 per cent  $\text{Al}_2\text{O}_3$  and 3 per cent  $\text{SiO}_2$ , 5 per cent of the alumina is lost and the silica content in the final product will not exceed  $\frac{1}{4}$  per cent. Verge reaches the same favorable result with a bauxite having twice the content of silica, and uses only a temperature of 125 to 135 deg. C. in the autoclaves. Peniakoff produces alumina, similarly to Deville-Pechiney, in a furnace. He uses a 30 m. rotating kiln, slightly inclined, and reduces a mixture of bauxite and sodium sulphate with coal at a temperature of 1200 deg. C. The acid fumes after having been exposed to the air and steam are passed over salt, producing sodium sulphate. The hydrochloric acid which is formed thereby is recovered as a by-product. The process is thereafter identical to Bayer's.

White bauxite, which contains up to 25 per cent silica and up to about 5 per cent iron oxide, is purified in an entirely different manner from the red bauxite. It is pulverized and slightly heated so as to make it more porous. Warm sulphuric acid of 1.45 sp.gr. is thereafter cautiously added to the bauxite, and aluminium sulphate is formed under violent boiling. Steam and water are then added to reduce the sp.gr. to 1.2. The iron is dissolved as ferrous or ferric sulphate together with aluminium, and if the bauxite contains

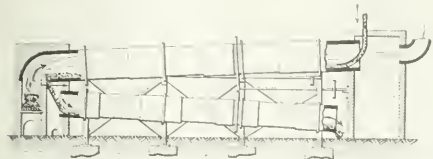


FIG. 7. CALCINING FURNACE

cined in an oven such as is shown in Fig. 7, where the vegetation matter is burned off. The temperature is kept at 700 deg. C. and may not exceed 900 deg. C. as the higher burned alumina is less easily dissolved in the caustic solution. The calcining oven is about 10 m. long and has a diameter of about 1 m. The slope is 1 : 25 and the rotation is very slow. The lining consists of fireproof brick. The material is fed at the upper end of the upper tube and passes through the same in the opposite direction to the flame. The cooling takes place in the lower tube, which is smaller than the upper one. The bauxite is thereafter pulverized and sifted. The Verge process eliminates the preliminary treatment.

In the Bayer process the bauxite is now put into an autoclave and subjected to the action of a caustic soda solution of 1.45 sp.gr. It is heated with steam at 5 to 6 atmospheres pressure and agitated for two to three hours, the temperature being from 150 deg. to 160 deg. C. A solution of sodium aluminate is thus formed and is diluted to a sp.gr. of 1.23, from which the insoluble iron oxide is separated. The filtered sodium aluminate solution is then not treated, as in the Deville-Pechiney process, with carbon acid, but the diluted (1.23 sp.gr.) solution is agitated for 36 hours with a small quantity of freshly precipitated hydrate of alumina. This is done in autoclaves, such as shown in Fig. 8, having a diameter of about 4 m. and a height of about 6 m. About 70 per cent of the dissolved alumina is thus precipitated from the caustic and separated by filtration.

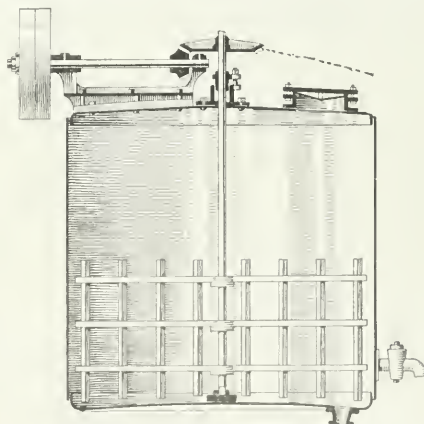


FIG. 8. AUTOCLAVE USED IN CAUSTIC PROCESS

magnesium, this is also dissolved. After it has been determined that no free sulphuric acid remains, the silica is separated.

The iron can be separated in different ways, either before solution, by oxalic acid, or after the decantation, with ferrocyanide of potassium or calcium sulphide. The aluminium sulphate solution is evaporated and the sulphate calcined in reverberatory furnaces.  $\text{SO}_2$  or  $\text{SO}_3$  is liberated during the heating and is again changed to sulphuric acid. The alumina which remains is non-hygroscopic and can be used directly for making aluminium. For satisfactory aluminium production the refined ore should contain at least 98 per cent  $\text{Al}_2\text{O}_3$ , not

The hydrated alumina is then filter-pressed under a pressure of 5 atmospheres, and the product is thereafter air-dried and calcined in tubular kilns, lined with magnesite brick. These kilns are about 6 m. long, have a diameter of 1.8 m. and are fired with gas. Even though the water is driven out at a low temperature, the alumina is heated to red heat at a temperature of about 1100 deg. C., as the alumina thereby becomes only slightly hygroscopic and can be used directly for production of aluminium. The diluted soda solution is again brought up to a sp.gr. of 1.45 in vacuum stills and can then be used again.

With both Deville's and Bayer's method it is necessary to use a bauxite with a low silica content, as too

more than 0.3 per cent  $\text{SiO}_2$  or 0.1 per cent  $\text{Fe}_2\text{O}_3$  and not more than 1 per cent  $\text{H}_2\text{O}$ .

Hall, in America, in connection with the Pittsburgh Reduction Co., has used a more direct method for purifying the bauxite. He uses an electric arc furnace constructed somewhat on the same principles as a carbide furnace. The bauxite is first calcined and mixed with 10 to 15 per cent carbon depending on its impurities. At the temperature of the electric furnace the silica, iron oxide and eventually the titanium oxide are reduced and also part of the alumina. There is formed a fluid alloy of iron, silicon, titanium and aluminium which sinks to the bottom and is drawn off. This alloy constitutes a valuable by-product. This simple method is reported to be feasible for the use with clay or aluminium silicates. The purified alumina will, however, not be as pure as by the chemical processes, and will not dissolve as readily in the cryolite bath.

Cowles and Kayser have also used the electric furnace for producing pure alumina. Kaolin, feldspar or clay was mixed with sodium chloride or calcium chloride in the ratio of 18 parts pure alumina to 23.4 parts salt, and in order to get the reaction to proceed more rapidly 15 per cent charcoal, produced from sawdust, was added. Briquets of this mixture to which some water was added were exposed to a temperature in the furnace corresponding to the temperature of volatilization of the salt. The oxidizing action of the steam prevents the sodium from escaping and there is formed a sodium-silica-alumina composition, and hydrochloric acid is evolved.  $2\text{SiO}_2$ ,  $\text{Al}_2\text{O}_3$  plus  $4\text{NaCl}$  plus water and carbon =  $2\text{SiO}$ ,  $\text{Al}_2\text{O}_3$ ,  $2\text{Na}_2\text{O}$  plus  $4\text{HCl}$  plus water and carbon oxide.

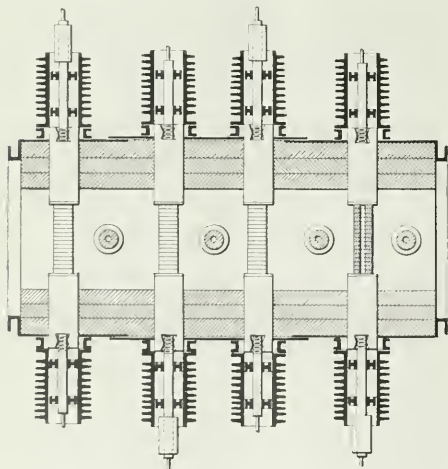
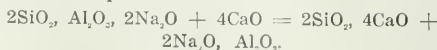


FIG. 9. SERPEK NITRIDE FURNACE

The hydrochloric acid is condensed to 18 deg. Baume and the salt as well as part of the aluminium chloride is recovered in chambers. After this, the mass is treated with lime in a revolving furnace and the following reaction takes place:



An excess of lime will form an insoluble calcium aluminate, while a shortage will cause part of the

insoluble sodium-silica-alumina composition to be unchanged. The alumina is separated from the soda solution and treated in the usual manner. The silica-lime composition can be used as a by-product for glass and cement manufacture. The hydrochloric acid can be used for producing a double chloride of aluminium and potassium by utilizing the feldspar.

Dr. Serpek, before the war, made very good progress with the AlN reaction in the production of both alumina and ammonia. He demonstrated the great affinity of aluminium for nitrogen at high temperatures. In conjunction with Badin, Dr. Serpek worked intensively

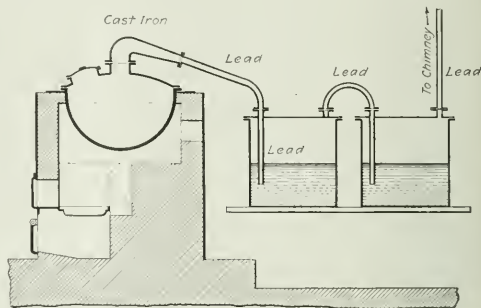


FIG. 10. HYDROFLUORIC ACID STILL

with large revolving furnaces or kilns, in which alumina was acted on by carbon and nitrogen at temperatures from 1600 to 1800 deg. C. By using a catalyst, such as iron and steam, it was possible to start the reaction even at 1300 deg. C. The furnace is lined with aluminium nitride, and the cross-section of an actual furnace is shown in Fig. 9. The electric resistance consists of carbon disks. There are eight columns, each 1.2 m. long, which are connected in series, and which take 10,000 amperes at 230 volts direct current. This gives a temperature of 1800 deg. C. in the furnace. The reaction is as follows:



When this aluminium nitride is treated in an autoclave with steam under pressure, it gives alumina and ammonia,



After the ammonia has been liberated the alumina can be used over again in the furnace. If, on the other hand, it is desired to use the alumina for producing aluminium, then the aluminium nitride is mixed with soda lye and the ammonia is liberated at 2 atmospheres pressure after from 2 to 2½ hours. The ammonia may be used for producing nitric acid, ammonium nitrate or ammonium sulphate.

The alumina is treated further according to the Bayer method. The treatment in the autoclaves is, however, simpler, as, according to Serpek, only 2 atmospheres pressure is required instead of 8 atm. The process is shorter and the concentration only 20 deg. B. instead of 40 deg. B. It is, therefore, claimed that the Bayer-nitride process costs only 63 fr. per ton of aluminium as compared to 126 fr. for the old Bayer process. This does not, however, include the cost of the bauxite. Besides this, ½ ton of nitrogen is fixed per kw.-year, cor-

responding to 2 tons of alumina. It will be of great interest to follow the results obtained by the aluminium-nitride process, and in this connection it may be of interest to learn that the Société Générale des Nitrures is also experimenting with ferro-aluminium, which has shown tendencies to combine with nitrogen, the reaction being exothermic. It is unfortunate that Badin has recently died. It is doubtful whether Dr. Serpek is continuing his experiments in Paris or St. Jean de Maurienne.

The subject of producing a pure alumina has been dealt with rather in detail, but it is absolutely essential that this part of the problem is thoroughly understood before one can have any hope of a satisfactory aluminium production. A number of prominent chemists are constantly working on this important problem.

#### CRYOLITE AND BATH FLUXES

Before proceeding to the electrode question, a few words may be said about the cryolite in which the alumina is dissolved. The natural cryolite, such as it is found at Tvigtut, Greenland, or at Miask, in the Urals, has the chemical formula  $\text{AlF}_3 \cdot 6\text{NaF}$ . The chief impurities are quartz, iron and lead, and it is mechanically purified by hand picking and with electro magnets. As obtained from the chemical factories at

shown in Fig. 10. The hydrofluoric acid causes bad burns and attacks the mucus membrane. One must therefore be extremely careful when working with it, and precautions such as wiping the hands with vaseline or the use of gas masks are to be recommended.

The fluorspar should not contain silica or silicates, as the formation of silicon-tetra-fluoride would result, which changes over to colloidal silicic acid, which renders the aluminium impure. The silica can, however, be removed by fluoride of potassium.

As the bath in the aluminium furnaces constantly loses fluorine, this must be replenished. If, however, fluorine was added in the form of cryolite, the bath would gradually be richer in sodium, which would go into the aluminium. Aluminium with only  $\frac{1}{100}$  per cent of sodium is brilliant, while a content of  $\frac{1}{10}$  per cent makes it dull and the utensils made therefrom will take on a dark color.

Aluminium fluoride,  $\text{AlF}_3$ , is therefore added from time to time to the bath, this being produced from hydrated alumina and hydrofluoric acid or aluminium sulphate and cryolite. Natural calcium fluoride, i.e., fluorspar, is also used.

#### MANUFACTURE OF CARBON ELECTRODES

The electrode production in an aluminium factory is of utmost importance inasmuch as the electrode consumption equals the weight of the aluminium produced. The electrodes must furthermore be of a special grade in that the ash content should not exceed 1 per cent. For an economical aluminium production, it is advisable to erect an electrode plant near the aluminium works, as in this manner it will be possible to use the waste from the old electrodes, which may amount from 10 to 30 per cent of the total consumption.

Ordinary coal or coke cannot be directly used for the manufacture of electrodes, as even the purest anthracite will give electrodes having an ash content of more than 2 per cent, of which at least 13 per cent is silica. Natural graphite or baked carbon is not sufficiently pure, and graphite is in general too expensive for aluminium production in that its high electric conductivity cannot be utilized. The current density should be from about 0.6 to 1.0 ampere per sq.cm. and even a lower density is often used. The consumption is not reduced by using graphite, because it is the oxidation during the electrolysis which consumes the electrodes. Retort graphite may be used, but this contains as a rule too much silica, so that it is used in addition to other materials. Acheson graphite is very pure, but is now too expensive in Europe. In general petroleum coke is the best material, although it is high priced. It has a low ash content of from 0.1 to 0.4 per cent and seldom goes over 0.5 per cent. The American petroleum coke is generally purer than the Rumanian. It is produced by distilling heavy crude oil which is heated to a dark red heat, the product being a porous, partly hard and partly soft shining mass with a grain-like structure.

Petroleum coke contains 10 to 15 per cent of readily volatile matter, or even as high as 20 per cent. This volatile matter must first be driven out by calcining at red heat, otherwise it is impossible to obtain good solid electrodes. The larger pieces of the coke are first crushed in ordinary crushers to the size of a walnut. The ovens, such as designed by Frans Meisser, are about

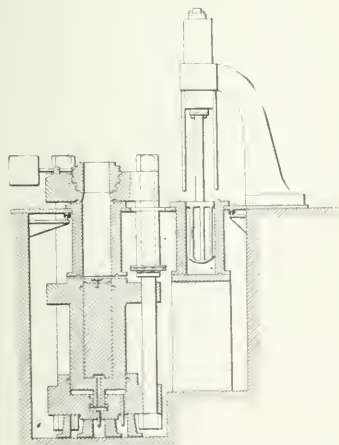


FIG. 11. VERTICAL ELECTRODE PRESS

Oresund or La Compagnie des Produits Chimiques d'Alais et de la Camargue, it contains about 50 per cent fluorine and 12 to 13 per cent alumina, but only  $\frac{1}{4}$  to  $\frac{1}{2}$  per cent silica and  $\frac{1}{10}$  per cent iron.

Cryolite melts at about 1000 deg. C., and when heated to red heat it liberates up to 1 per cent of water. At white heat sodium fluoride and fluorine will gradually escape and the alumina will be left. The artificial cryolite contains more fluorine, its chemical formula being  $\text{AlF}_3 \cdot 4\text{NaF}$ . It is, therefore a better raw material, but it smokes more. It is produced by treating hydrated alumina and ordinary salt with hydrofluoric acid or by other methods. The hydrofluoric acid must first be produced and is made by distilling a mixture of pulverized fluorspar with concentrated sulphuric acid, the HF being absorbed in water. Such a still is



5 x 6 m. and about 6 m. high with 8 retorts having an inside diameter of about  $\frac{1}{2}$  m. These retorts are filled from the top and emptied successively every three to four hours through water-cooled passages in the bottom. The retorts are heated by gas, which first passes through an economizer, which comprises one-half side of the oven. The preliminary heating takes nine to twelve hours.

After the calcining, the petroleum coke, together with the old waste electrodes, is pulverized and some retort graphite is added. If the pieces are large it may first be necessary to pass them through crushers, and thereafter pulverize them in ball mills. The petroleum coke is now mixed with up to 20 per cent of a pitch binder. Some plants use tar thickened with about one-third pitch. A little soot will make the electrodes more homogenous, but it is as a rule likely to be too impure. In order to protect the electrodes from burning it is also recommended that a little alumina be added. If the tar contains water, it should first be heated to evaporate it. Coal tar pitch obtained from coke ovens may be used, as it contains not over 1 to 2 per cent of ash, but one must be careful and not use blast furnace tar, which often contains as high as 20 per cent of ash.

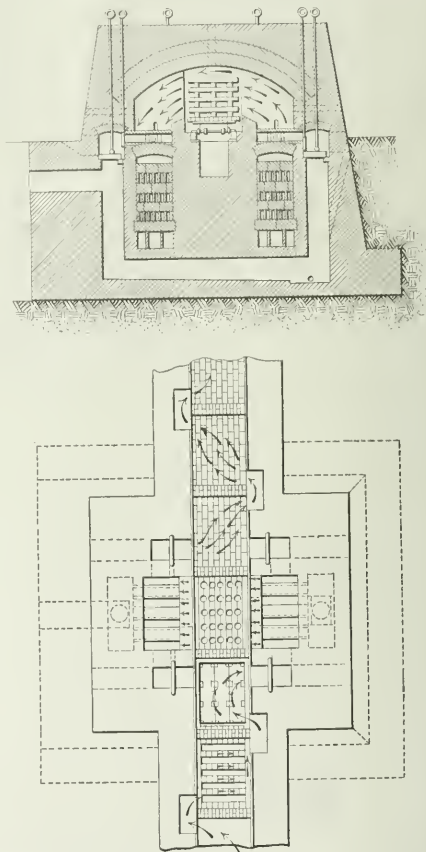
The substances are mixed in steam heated kneading machines. Such a machine has two Z-shaped kneaders, which rub on each other and the steam jacketed chamber walls. When the mixture is sufficiently kneaded the container is opened and the mass brought by a conveyor to the molds or presses. In these they obtain their final form and compactness, the pressure being up to 500 atmospheres. The higher the pressure, the more compact will the electrodes be and the less binder will be required, which is an advantage, as the space occupied by the binder will always be more or less void when the electrodes are baked and the tar oils volatilized.

The construction of the presses depends naturally on the size of the electrodes. In an aluminium furnace it is advisable to use several electrodes so as to make it possible to make renewals without breaking the current or lower the potential. Several furnaces or ovens, up to 40, may be connected in series and the electrodes are constantly being changed and adjusted. If the current had to be broken at each change of electrode, a continuous operation would be impossible. The size of the electrodes depends both on the number and on the electric current which the furnaces require. From 8000 to 10,000 amperes is common, while much larger sizes are in use, requiring a current of from 15,000 to 20,000 amperes. The cross-section of the electrodes varies from 20 x 20 sq.cm. to over 40 x 40 sq.cm., and the length may be more than 1 m., although it is common practice to use a nearly cubical form for the larger sizes.

The electrode press, shown in Fig. 11, is of the vertical type and equipped with a preliminary press and a turntable. The cylinder is first packed full with the mixture by the outer piston and then moved to the middle position, where the center piston presses it through the mouthpiece. If short electrodes are desired, they are simply cut off to the required length. Such a press is about  $4\frac{1}{2}$  m. high and takes up a floor space of 4 to  $5\frac{1}{2}$  m. It can press the largest electrodes needed for the aluminium industry.

Another method is that of pressing the short electrodes directly in a mold, in which case the mass does not pass through any mouthpiece. There are many designs of vertical and horizontal electrode presses with or without preliminary presses, but as a rule the simplest and the strongest are the best.

After the electrodes have been pressed and formed they are baked in furnaces. This makes them solid, compact and highly electro-conductive due to the re-



FIGS. 12 AND 13. CROSS-SECTIONS OF MENDHEIM-JEHL ELECTRODE FURNACE

moval of the insulating tar oils. The heating must be done slowly, otherwise they may be less compact and may easily crack. Thus, for example, several days are required for firing the larger electrodes. The temperature is gradually raised to more than 1400 deg. C. and during the operation the electrodes lose about 10 per cent of their weight.

Modern European furnaces are gas fired and the electrodes are protected by being placed in crucibles of a refractory material. The empty space around them is filled with retort graphite, which is a good heat conductor, or with pulverized petroleum coke or electrode waste.

Much experimenting has been done to do away with the gas producer and to get the gas from the fresh pe-

troleum coke in the retorts. No satisfactory method was, however, found until a few years ago, as the mass shrunk so much that the electrodes became directly exposed to the flames.

Of the many different furnace designs may be mentioned Mendheim's muffle furnace of the Bock type, where the electrodes are passed through a passageway toward the center of the furnace, where the heat is greatest. The electrodes are placed on trucks, which thus are pushed through the furnace by hydraulic pistons. They are preheated by the waste gases and cooled by the air required for the furnace draft, which in this manner also becomes preheated. The electrodes are

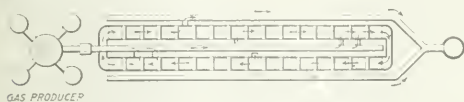


FIG. 14. MEISSER FURNACE

baked in this furnace at a temperature of 1350 deg. C., which is sufficient for electrodes to be used in aluminium reduction where the temperature of the bath is around 1000 deg. C.

A modification of the above furnace has been devised by Jehl, and consists of a system of partitions or chambers. Figs. 12 and 13 show the center portion of such a furnace where the baking takes place. The tunnel on both sides of the furnace has a similar section; and the waste gases pass the economizer on one side and thus preheat the electrodes which are brought into the furnace. The air cools the finished electrodes and is further heated by the economizer.

The more generally used ring-furnace is that of Frans Meisser. As seen from the diagrammatic sketch in Fig. 14, it consists of sixteen chambers on each side

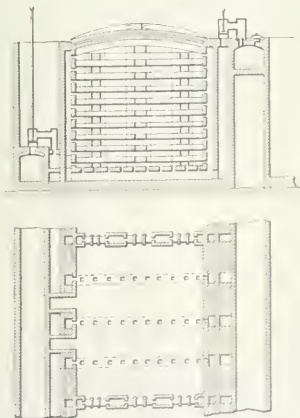


FIG. 15. SECTION OF MEISSER FURNACE

of a gas flue. These chambers may be 2 m. long, 1.5 m. high and 1.5 m. wide, or even larger. Two of the chambers are always idle for taking out finished electrodes and for putting in new ones and can be separated from the others by removable partitions. Fresh air enters the furnace from neighboring chambers and is heated in the next five or six chambers, while these as

well as the electrodes therein are cooled. In the next or next two chambers the producer gas is burned and gives off its heat to the following six chambers, after which the waste gas passes off through the chimney.

In the other side of the furnace the process is similar, and as the electrodes are baked and replaced by fresh ones the chambers are cut in and the neighboring one opened and emptied, and so on, according to a predetermined cycle of operation.

Fig. 15 shows the construction of the furnace, the gas flue being in the center between the two rows of chambers. By means of a double elbow pipe the gas is led down and out through the small openings, where it meets the air and burns. The air has entered in the previous chamber, where the pipe has been removed. When a chamber is to be emptied, inspected or recharged, the cover is removed by a traveling crane; the partitions which separate the chamber from the rest must, however, first be put in place.

Mendheim has recently designed a ring-furnace, where retorts are unnecessary in that the chambers

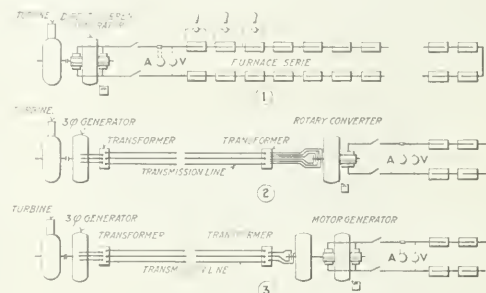


FIG. 16. TYPES OF ELECTRIC INSTALLATION

themselves serve this purpose. They are surrounded by hollow walls through which the gases pass. Fresh coke is used as the packing filler and is tamped tight around the electrodes to such a thickness over them that they will not become exposed when the coke shrinks down. The most remarkable feature of his furnace is that after the material has become ignited for a time by the aid of a small gas-producer the latter can be shut down and the distillation gases from the volatile matter in the binder of the electrodes and the coke filler can be utilized for heating the furnace itself. It is claimed that the gas supply is more than sufficient to bring the furnace temperature up to the highest values.

#### THE ELECTRIC INSTALLATION

The raw materials for aluminium production, i.e., alumina, cryolite and the electrodes, have been dealt with in the above, but in addition to these a large supply of direct current is required for electrolysis and heating the furnace. Each aluminium furnace takes from 6½ to 7½ volts, and in starting it requires wider limits, from 5½ to 8½ volts. It is, of course, not economical to build generators of such a low voltage and from 30 to 40 furnaces are, therefore, connected in series. The operating voltage for 35 furnaces in series will, therefore, be about 250 volts.

As is apparent from diagram 1 in Fig. 16, it is preferable if the aluminium works can be located near the

power house. The direct current generator can then be directly driven by the turbine and the current delivered economically to the furnaces. The regulation from zero volts up to maximum is accomplished simply

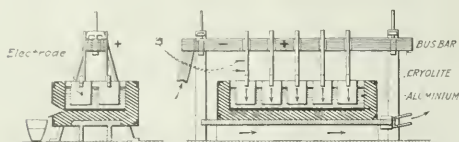


FIG. 17. VERTICAL SECTIONS OF ALUMINIUM FURNACE

by a field rheostat. If several generators are required, they may be operated in parallel. If there are several series of furnaces, these can then be operated independently of one another. This simple arrangement should be used if the waterpower is located near a port, while if it is located in the interior, it depends on the local transportation facilities whether the factory should be built near the power house or not. If not, the energy may be transmitted over a transmission line according to diagram 2 or 3. In both these cases the turbine drives a 3-phase alternating current generator, and if the distance between the factory and the power

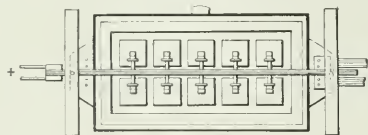


FIG. 18. HORIZONTAL SECTION OF ALUMINIUM FURNACE

station is great, it may be necessary to step-up the voltage to a higher value by means of transformers.

In diagram 2 the conversion of the 3-phase alternating current to direct current is accomplished by a synchronous converter, and in diagram 3 by a motor-generator. The former gives a little higher efficiency, but the direct current voltage cannot be regulated from zero and up, and if adjustments are required, the trans-

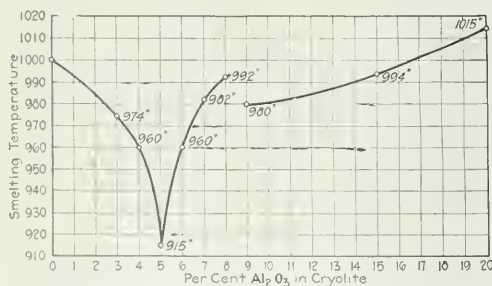


FIG. 19. MELTING POINTS OF ALUMINA-CRYOLITE

former taps must be changed or a booster must be provided. This is connected in series with the alternating current supply circuit, and by increasing or decreasing its field excitation, the voltage which is applied to the converter terminals is raised or lowered, thus also raising or lowering the direct current voltage. Synchronous converters are mostly used in America and England, and motor-generators on the Continent.

As shown in Fig. 16, voltmeters and incandescent

lamps are used for reading the voltage of each furnace, and the current, which is, of course, the same for all the furnaces in the series, is measured by an ammeter and the main potential by a voltmeter. The instruments on the alternating current side are not shown.

### THE MANUFACTURE OF ALUMINIUM

The aluminium furnace in Figs. 17 and 18 has the electrodes supported by means of copper bars from a set of crossbars. The vertical bars are fastened to the crossbar by means of clamps and bolts or keys and to the electrodes by means of a bolt which is screwed or molded into the electrode. The furnace casing is lined with carbon and the current enters from the crossbar, through the furnace and down to the iron bottom which comprises the negative pole.

To start the operation the electrodes are all lowered, the current is thrown on, and as the furnace heats up it is filled with cryolite, which melts. If the bath gets

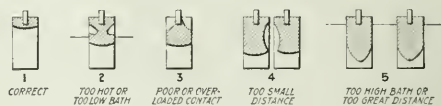


FIG. 20. ELECTRODE CONSUMPTION

too high, the electrodes can be raised by adjusting bolts. The furnace is tapped or scooped out every third or fourth day, the ingots varying in size from 2 to 40 kg.

The cryolite melts around 1000 deg. C., but if a little alumina is dissolved therein the melting temperature drops as shown in Fig. 19, the melting point being at a minimum with 5 per cent alumina dissolved. With from 8 to 9 per cent alumina a break in the curve seems to occur, and the cause of this is probably that the composition of the cryolite has been changed. If aluminium fluoride is added, the temperature will drop still further, and aluminium fluoride will also more readily dissolve the alumina. With 20 to 30 per cent alumina, the bath becomes thicker and there is danger that the alumina may only not dissolve but sink to the bottom, whereby the resistance will increase and cause local heating, or the aluminium together with the carbon may

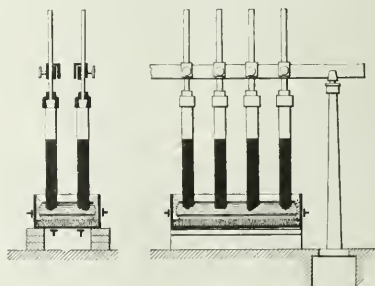


FIG. 21. ALUMINIUM FURNACE USING CRYOLITE CRUST FOR CONTAINER

form a carbide,  $\text{Al}_4\text{C}_3$ . This aluminium carbide, which generally is formed when the operation is carried on at too high a temperature, is yellow and of hexagonal crystallization. When mixed with water at ordinary temperature, it forms slowly alumina and methane gas.



Moisan has therefore drawn the conclusion that the methane vapors which issue from the ground may be caused by aluminium carbide in the interior of the earth.

The temperature is also of importance as far as the electrode consumption is concerned, and as shown in diagram 2, Fig. 20, at an excessively high temperature the air will quickly oxidize the electrode. Not enough

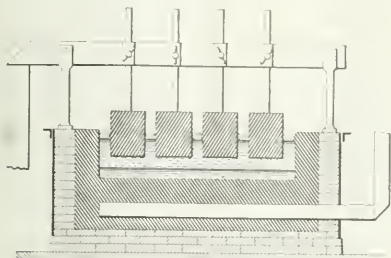


FIG. 22. UNIT NEGATIVE ELECTRODE AND CONTAINER

distance between the electrodes creates a condition as shown in diagram 4. If the bath is too high, the electrodes will be pointed, as in diagram 5, and if the contacts are poor, they will take a shape as in diagram 3. Diagram 1 shows the desired form.

The temperature also affects the composition of the bath in that at high temperatures the fluorine evaporates and must be replaced by aluminium fluoride. At a low temperature, a hard crust is formed over the bath. As the aluminium melts at from 625 to 700 deg. C. it may be difficult to draw off the metal at a low temperature, or it may rise in the bath and cause a short circuit of the furnace. When aluminium approaches the solid state, it becomes lighter than the bath, while in a molten form it is slightly heavier. For these reasons it is often necessary to cut out a furnace of the series, and it happens also that a hole is burned therein or that the electrodes get stuck or "freeze," so that they cannot be regulated. One electrode may then get too much current or the copper connections may melt, and if things go wrong all the copper bars, one after the other, may melt. If it has been decided that a furnace is to be cut out, this can be done by connecting both

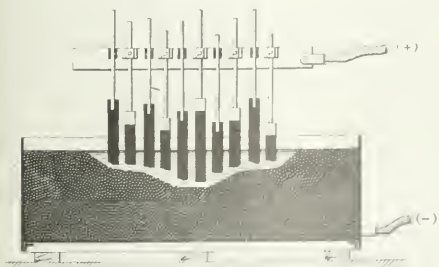


FIG. 23. HALL'S ORIGINAL FURNACE

and the current in the series may be reduced until the new furnace is hot enough to melt the cryolite.

The temperature has also to do with the electrode consumption, and carbon monoxide is formed at high temperatures and burns with a blue flame, which also may be yellow on account of the sodium present. At ordinary temperatures between 800 and 1000 deg. C. carbon dioxide is also formed. The proportion of the volume of the waste gases varies from 5 to 10 and even up to 20 parts of carbon monoxide for 100,000 parts of carbon dioxide. It has, however, been proved that these gases are not dangerous to the operators in the furnace room.

The formation of the carbon dioxide occurs from the electrolysis of the dissolved alumina, and if all the alumina is decomposed the electrolysis may proceed with the aluminium fluoride. The fluorine forms then with the anode carbon tetrafluoride, a gas which is dissolved in water without being decomposed. This gas is, however, harmless. In any case, the furnace operator notices immediately when the alumina is consumed, as the furnace voltage rises from the normal 7 volts up to around from 15 to 17 and even up to 20 volts. The

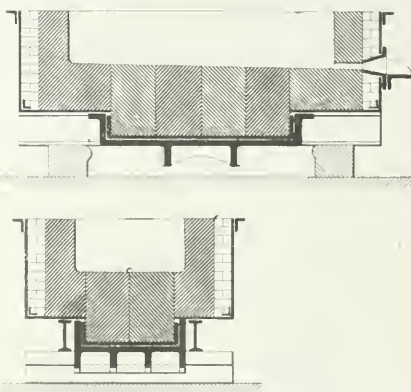


FIG. 24. LAMBERT'S FURNACE

incandescent lamp brightens up, the voltmeter needle swings over and the operator knows that more alumina must be added to the bath.

It has never been possible to find hydrofluoric acid in the gases from the aluminium furnaces. It was thought that hydrofluoric acid was the cause of the windows becoming dull, but when the bath or the electrodes contain some silica, the gases were found to contain about 20 per cent of silicon-tetrafluoride. This gas, due to the moisture in the air, will attack glass and make the windows dull; it also attacks copper in the neighborhood of the furnace and blackens it. The pine trees near the factory suffer also somewhat from the gases.

When a furnace gets "hot," for example over 1000 deg. C., a process takes place which is opposite to that which takes place when aluminium is produced. At higher temperatures the sodium fluoride of the bath is reduced, the sodium rises to the surface in small balls and burns with a lively yellow flame. With "hot" furnaces the aluminium will quickly dissolve the iron rakes which are used. A 900 to 950 deg. C. temperature of the bath seems to be the best, although some advocate

the terminals to the bar or by using jumper connections. In this manner it is possible to short circuit a furnace and disconnect the same without disturbing the rest of the series. A new furnace can be cut in in the same manner, the electrodes may be lowered to the bottom

a lower temperature, 800 to 900 deg. C. The furnaces will then, however, be much more difficult to operate. Each operator can take care of from four to five furnaces.

Fig. 21 shows a frequently described furnace without carbon side linings. The intention is that the cryolite bath shall get hard and insulate the iron sides, but if it does not, the result is that there will be an iron content in the aluminium and the furnace may readily be damaged.

Fig. 22 shows how the negative terminal can be molded into the bottom mass. This construction is, however, used in only a few places.

Fig. 23 illustrates Hall's furnace, which, however, is of only historical interest commercially.

Fig. 24 is Lambert's furnace, the bottom of which consists of electrodes fitted into a cast-iron frame. This construction is still in use.

#### INDUSTRIAL APPLICATIONS OF ALUMINIUM

Aluminium can readily be cast and fills the molds well. When nearing its melting temperature it gets doughlike and contracts about 1.8 per cent in volume. By shaking it between 550 and 625 deg. C., it pulverizes. It is also generally resmelted if it is to be

larger and larger furnaces having capacities of several tons.

Aluminium can be resmelted without taking up gases and without forming blowholes, but it gets covered with a thin film of oxide. Its purity should not be less than 98 per cent, and if it is to be used for rolling,

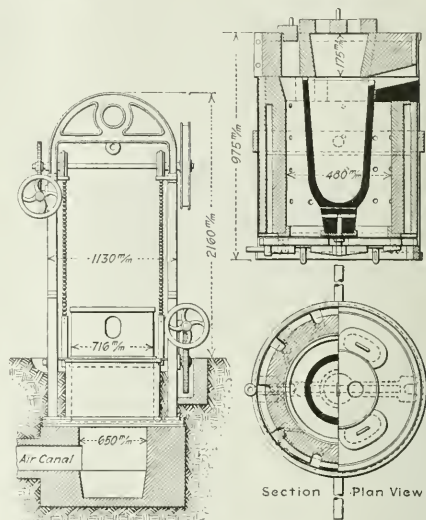


FIG. 26. CROSS-SECTIONS OF ROUSSEU'S FURNACE

where strength is essential, its purity should preferably be 99 per cent.

High-grade aluminium which does not contain more than  $\frac{1}{100}$  per cent sodium,  $\frac{1}{100}$  per cent iron and  $\frac{1}{2}$  per cent silica can be forged, rolled, drawn or punched, and can also be brazed and soldered. Aluminium may, therefore, take the place of tin foil and in certain countries aluminium money is used instead of nickel. In America aluminium is extensively used for cans for fruit and other conservation, and in Sydney they use an aluminium alloy, called Ormiston, for this purpose entirely.

Aluminium is used in the form of sheets, pipes, cables or cast parts for automobiles, aeroplanes, etc., and pipes for carrying nitrous gases. Due to its lightness (2.7 against 8.9 for copper), its conductivity (34 against 57 for copper) and its comparative strength (22 against 44 for copper), aluminium is rapidly replacing copper in the electrical industry. To get the same conductivity only one-half the weight of aluminium is required as of copper. In reality aluminium is, therefore, twice as good a conductor as copper, when the conductivity is compared to the weight. As, furthermore, this one-half the weight of aluminium occupies a greater volume than copper, it follows that the heat radiation of a transmission line must be better than a copper line. An aluminium conductor can also better withstand the stress caused by its own weight, as its low specific weight in this case is of greater importance than its lower strength.

According to the law of Faraday, the production of 1 kg. aluminium requires 2969 amperes for one hour,

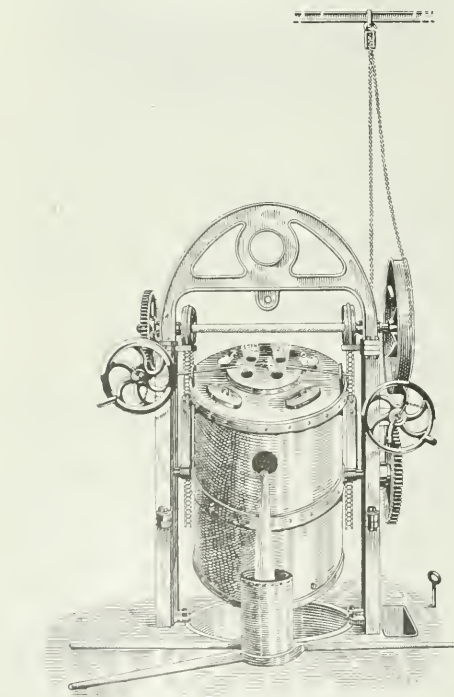


FIG. 25. ROUSSEU'S FURNACE

rolled or pressed, and the Rousseu furnace is widely used for this purpose, the construction being shown in Figs. 25 and 26. The retort is of graphite and the furnace is fired with coke. Plates up to 1.10 x 1.10 x 0.12 m, weighing from 300 to 400 kg. may be cast for use in rolling large sheets and the tendency is to construct

but in actual practice 5 to 10 per cent more is required. The voltage needed for the melting of the alumina is, according to Thomson, 2.8 volts, and from this must be subtracted the potential for the formation of the carbon dioxide and carbon monoxide, and to it must be added the potential corresponding to the resistance of the furnace and which heats the bath. In practice the total voltage is figured to be between 6.5 and 8.5 volts, but if extra long electrodes are used the voltage may be still higher. One kg. of aluminium has been produced with 25 kw.-hours, but 33-35 kw.-hours per kg. may be considered a good result.

The alumina consumption is theoretically 1.888 kg. per kg. aluminium and in practice 1.95 to 2 kg. The theoretical electrode consumption is 0.666 kg. or 0.333 kg. per electrode per kg. of aluminium, depending on how much carbon monoxide or carbon dioxide is formed. If the waste is subtracted, the consumption will go below 0.666 kg., which proves that carbon oxide is formed. An electrode consumption of from 0.7 to 0.9 kg. per kg. aluminium with a salvage of 0.2 to 0.3 kg. may be considered a good result.

#### COST

In order to give an idea of the various items which enter into the cost of manufacturing aluminium, the following tabulation has been prepared. It is, of course, greatly dependent on local conditions, and refers to normal conditions before the war:

| Per Kg. Aluminium                 | Frs  |
|-----------------------------------|------|
| 55 kw. hours at 0.7 centimes..... | 0.25 |
| 2 kg. alumina at 0.25.....        | 0.50 |
| 0.8 kg. electrodes at 0.35.....   | 0.28 |
| 0.12 kg. cryolite at 0.40.....    | 0.05 |
| 0.05 kg. fluorine at 0.50.....    | 0.03 |
| 0.25 Working hours at 0.60.....   | 0.15 |
| Miscellaneous.....                | 0.15 |
| Total: Frs. ....                  | 1.41 |

#### WORLD'S PRODUCTION OF BAUXITE (TONS)

| Country              | 1913    | 1915    | 1917    |
|----------------------|---------|---------|---------|
| United States .....  | 210,241 | 297,041 | 568,690 |
| France .....         | 304,314 | .....   | .....   |
| United Kingdom ..... | 8,282   | 11,723  | 14,724  |
| Italy .....          | 6,841   | 5,807   | .....   |
| India .....          | 1,184   | 876     | .....   |
|                      | 530,862 | .....   | .....   |

By this table it will be seen that the United States is assuming a leading position in the production of bauxite.

## Industrial Reconstruction in Great Britain

ON NOV. 12 last, one day after the armistice was signed, a Parliamentary paper was issued in London announcing the appointment of an Advisory Council and other councils and committees by the Minister of Reconstruction. The Advisory Council consists of a panel of men and women of mature experience and distinction in affairs. It is divided into five sections, each of which meets once a week. Their purpose is to advise on questions of special difficulty or complexity that may come before the Ministry. An informal committee of women members of the Council will meet regularly to give advice as desired in connection with questions affecting the position of women. The five sections relate respectively to (1) Finance, Transport and Common Services, (2) Production and Commercial Organization, (3) Labor and Industrial Organization, (4) Rural Develop-

ment, including Agriculture, and (5) Social Development, including Health, Education and Housing.

Another Council was appointed which has to do with the disposal of surplus Government property.

The Engineering Trade Committee is also a creation of the Minister of Reconstruction, and its purpose is "to compile a list of the articles suitable for manufacture by those with engineering trade experience or plant which either were not made in the United Kingdom before the war but were imported or were made in small or insignificant quantities in the United Kingdom and for which there is likely to be a considerable demand after the war." These are classified as to whether they are capable of being made by women, or by men and women, or by skilled men. The committee is to set forth where such industries may be most suitably attached, to make recommendations on their establishment and development by transfer of labor and machines or otherwise, and how such transfers may be made, as well as what organization is requisite with due regard to securing the coöperation of labor.

In this connection the following branch committees have been appointed: Wire Machinery, Printing Machinery, Printers' General Machinery, Papermaking Machinery, Leather Manufacturing Machinery, Textile Machinery (one in Manchester and one in Nottingham), Machine Tools, Agricultural Machinery, Aircraft, Hollow-ware and Sheet Metal and Pressed Work (one committee), Electrical Apparatus, Scientific Instruments, Miscellaneous Machinery and a General Labor Panel.

Still another series of committees has been appointed to consider and report upon the nature and amount of the supplies and foodstuffs required by the United Kingdom between the close of the war and the restoration of normal conditions, having regard to the requirements of India, the Dominions and Crown Colonies, the probable requirements of belligerents and neutrals at the close of hostilities, the sources from which they may be obtained and whether any measure of control will need to be exercised, as well as the measure and extent of such control. These committees consist of ten bodies and will consider respectively aluminium, antimony, copper, lead, nickel, spelter, tin, ferro-alloys, asbestos and hides and skins.

A committee is appointed to inquire into the extent that building materials will be needed and to ascertain how and where they are to be procured.

A large committee of many members considers priority after the war. This is composed of employers and workmen and is already at work.

The Committee on Interim Industrial Relations proposed that in each industry which has reached a sufficient level of organization there be established a Joint Industrial Council, consisting of equal numbers of representatives of associations of employers and members of trade unions which shall be approved by the Government. A considerable number of such councils have been formed and the Minister of Reconstruction will consult them on questions affecting their respective industries. A still greater number are in process of organization. In regard to heavy chemicals a Joint Industrial Council has been set up which is represented on this special committee. It was formed at the suggestion of the Minister of Reconstruction to deal with technical and commercial questions falling outside the scope of the council.



# Graphic Method for Fortification of the Spent Acids Used in Making Nitrating Mixed Acids

BY D. LOPEZ AND A. A. SWANSON

THE USE of mixtures of sulphuric and nitric acids of definite composition, so-called "mixed acids" in the manufacturing processes, especially in the explosive industry, has steadily increased. The chemist has been called upon to make unlimited numbers of calculations in his work of revivifying the spent acid recovered from the nitration. Work of this nature becomes more or less involved; it is necessary to have available methods which permit of easy and rapid solution of acid problems and which possess a high degree of accuracy.

It is hoped that the brief theoretical development of the principles involved in the fortification of spent acids and their use graphically, as given in this paper, will arouse interest in this field particularly at this time and find favor among acid-control chemists.

In a mixed acid let:

N = lb. of  $\text{HNO}_3$  in 1000 lb. of mixed nitrating acid;

S = lb. of  $\text{H}_2\text{SO}_4$  in 1000 lb. of mixed nitrating acid;

W = lb. of  $\text{H}_2\text{O}$  in 1000 lb. of mixed nitrating acid;

$N_s$  = lb. of  $\text{HNO}_3$  in 1000 lb. of spent mixed acid;

$S_s$  = lb. of  $\text{H}_2\text{SO}_4$  in 1000 lb. of spent mixed acid;

$W_s$  = lb. of  $\text{H}_2\text{O}$  in 1000 lb. of spent mixed acid;

so that:

$N + S + W = 1000$  lb. of mixed nitrating acid;

$N_s + S_s + W_s = 1000$  lb. of spent mixed acid.

The following symbols shall be used:

$x$  = lb. of  $\text{HNO}_3$  added to revivify 1000 lb. of spent mixed acid;

$y$  = lb. of  $\text{H}_2\text{SO}_4$  added to revivify 1000 lb. spent mixed acid;

$z$  = lb. of  $\text{H}_2\text{O}$  added to revivify 1000 lb. spent mixed acid;

$X$  = lb. of  $\text{HNO}_3$  Aq. added to revivify 1000 lb. spent mixed acid;

$Y$  = lb. of  $\text{H}_2\text{SO}_4$  Aq. added to revivify 1000 lb. spent mixed acid;

$P_n$  = Per cent  $\text{HNO}_3$  in  $\text{HNO}_3$  Aq. used;

$P_s$  = Per cent  $\text{H}_2\text{SO}_4$  in  $\text{H}_2\text{SO}_4$  Aq. used;

$x = P_n X$ ;

$y = P_s Y$ ;

$F = (1000 + X + Y)$  lb. of refortified mixed acid;

$W_s$  = lb. of water in  $F$  lb. of refortified mixed acid;

$(N_s + x) + (S_s + y) + W_s + z = F$ .

This new mix will be equivalent to the required mixed acid composition when:

$$N_s \cdot x = \frac{NF}{1000}; S_s \cdot y = \frac{SF}{1000}; W_s + z = \frac{WF}{1000}$$

$$\frac{N_s}{N} \cdot x = \frac{S_s}{S} \cdot y = \frac{W_s + z}{W} \quad (1)$$

Substituting for  $x$ ,  $y$  and  $z$  in equation 1, we obtain

$$\frac{N_s}{N} \cdot \frac{P_n X}{S} = \frac{S_s}{S} \cdot \frac{P_s Y}{W} = \frac{W_s + z}{W} \quad (2)$$

The water introduced ( $z$ ) in adding the refortifying acids to 1000 lb. of spent acid may be expressed by the following equation:

$$Y(1 - P_s) + X(1 - P_n) = z = W_s - W_s \quad (3)$$

by transposition,  $P_n X = Y(1 - P_s) + X - W + W_s$ ,

and substituting for  $P_n X$  in the nitric ratio in equation 2 we have:

$$\frac{N_s + Y(1 - P_s) + X - W_s}{N} = \frac{W_s}{W}$$

transpose  $-W_s$  to the right and simplify,

$$\frac{N_s + W_s + Y(1 - P_s) + X}{N} = \frac{W_s}{W} + \frac{W_s}{N} = \frac{W_s(N + W)}{NW}$$

cancel  $N$  from the denominators and transpose  $N + W$ , to obtain the equation:

$$\frac{N_s + W_s + Y(1 - P_s) + X}{N + W} = \frac{W_s}{W} \quad (4)$$

If the term  $P_s$ , the per cent  $\text{H}_2\text{SO}_4$  in the  $\text{H}_2\text{SO}_4$  Aq. to be used in mixing, is assumed to be a constant in equations 4 and 5 obtained by referring  $\frac{W_s}{W}$  to equation 2,

$$\frac{S_s + P_s Y}{S} = \frac{W_s}{W} \quad (5)$$

it is readily seen that equation 4, on account of the presence of the variable parameter  $W_s$ , represents a system of straight lines parallel to each other. By similar reasoning it is seen that equation 5 represents another system of straight lines which are parallel to the  $X$  axis. By combining equations 4 and 5, we can eliminate the common term  $\frac{W_s}{W}$  and get an equation which is the

locus of all the points in which the systems 4 and 5 intersect. This locus is represented by the equation:

$$Y[P_s(N + S + W) - S] - SX + S_s(N + W) - S(N_s + W_s) = 0,$$

and by rearranging and substituting, with  $T$  and  $H$ ,

$$\frac{P_s(N + S + W) - S}{S} = T$$

$$\frac{S_s(N + W) - S(N_s + W_s)}{S} = H$$

the equation becomes  $TY - X + H = 0$  (6)

In equation 6,  $Y$  gives the amount of sulphuric acid of fixed strength  $P_s$ , and  $X$  the corresponding amount of nitric acid of unknown ( $P_n$ ) concentration. The determination of this develops as follows: By eliminating  $Y$  from the sulphuric ratio in equation 2 with the equivalent of  $Y$  from equation 3 we obtain:

$$\frac{S_s + P_s Y}{S} = \frac{W_s}{W} \quad (2)$$

$$Y = \frac{W_s - W_s - X(1 - P_n)}{1 - P_s} \quad (3)$$

$$\frac{W_s}{W} = \frac{S_s + P_s[W_s - W_s - X(1 - P_n)]}{S}$$

$$= \frac{S_s(1 - P_s) + P_s W_s - P_s[W_s + X(1 - P_n)]}{S(1 - P_s)}$$

$$\frac{W_s}{W}(1 - P_s)S - P_s W_s = S_s(1 - P_s) - P_s[W_s + X(1 - P_n)]$$

$$\frac{W_s}{W} = \frac{S_s(1 - P_s) - P_s[W_s + X(1 - P_n)]}{S(1 - P_s) - P_s W_s}$$

$$\frac{N_s + W_s + Y(1 - P_s) + X}{N + W} = \frac{S_s + P_s Y}{S}$$

Transposing the terms to the right member

$$NP_n Y + WP_n Y - SY(1 - P_n) - SX + S_s N + S_s W - S N_s - S W_s = 0$$

$$Y[P_n(N + S + W) - S] - SX + S_s(N + W) - S(N_s + W_s) = 0,$$

Since  $(N + S + W)$  is always equal to 1000 and  $S$  and  $P_s$  are constant;  $T$ , the tangent of the angle intercepted by the horizontal axis and the curve, must also be a constant.  $H$ , the intercept of the vertical axis, is usually positive, but the system is not altered when it is negative.



On a rectangular axis system  $XY$ , Chart I, trace a vertical line parallel to the  $y$  axis, denote this the  $P_n$  axis, and mark on it the strengths 0.98, 0.96, 0.94, etc., of the nitric acid. If parallels to the  $X$  axis are drawn through those points, intersecting parallels to the  $Y$  axis drawn through the values of  $X$ , a line drawn through the points of intersection will give the curve  $cd$ , Chart I, represented by equation 9.

Repeating the same operation with points  $X = 82.33$ ,  $Y = 110$ ,  $X = 45.57$ ,  $Y = 41.72$ , and uniting them by a straight line we obtain the curve  $ab$ , Chart I, represented by equation 8.

#### USE OF CHART I

Suppose that nitric acid of 88 per cent strength is available and that the spent and mixed acids are of strengths above mentioned, then in order to get the amounts in units of sulphuric and nitric necessary to build up the spent acid we proceed as follows:

At the point marked 88 per cent on Chart I, follow horizontally until intersecting the curve line  $cd$ , at  $m$ , from this point drop down parallels to the  $Y$  axis intersecting the straight line  $ab$ , and  $X$  the axis in  $n$  and  $p$  respectively; the first intersection  $n$  gives in the sulphuric acid scale the amount of 100 per cent sulphuric, and the second intersection gives the amount of nitric acid.

In the above instance the readings are as follows:

$X = 60.60$  units;

$Y = 69.68$  units;

Total = 130.28 units;

Spent acid used 1000.00 units;

Total mix made = 1130.28 units.

|                                           |                                                                                                                                  |
|-------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------|
| 60.6 units of 88% $\text{HNO}_3$ contains | $\left\{ \begin{array}{ll} \text{HNO}_3 & 53.33 \text{ units} \\ \text{H}_2\text{O} & 7.27 \text{ units} \end{array} \right.$    |
| 1000 units of spent acid contains         | $\left\{ \begin{array}{ll} \text{HNO}_3 & 175.00 \text{ units} \\ \text{H}_2\text{O} & 160.00 \text{ units} \end{array} \right.$ |
| and the total mix contains                | $\left\{ \begin{array}{ll} \text{HNO}_3 & 228.33 \text{ units} \\ \text{H}_2\text{O} & 167.27 \text{ units} \end{array} \right.$ |

therefore the percentage strength of the resulting mix is:

$$\frac{228.33}{1130.28} = 20.201 \text{ per cent } \text{HNO}_3$$

$$\frac{167.27}{1130.28} = 14.799 \text{ per cent } \text{H}_2\text{O}$$

Should other strengths of nitric than 88 per cent be used the same outline could be followed.

#### FORTIFYING ACIDS

Observing the curve  $ab$ , Chart I, it is readily seen that each point represents a mixture of sulphuric and nitric acids of definite strength and in definite amounts. Now these mixtures, high in nitric and low in water, are called fortifying acids, and can be obtained by reading the amounts on the chart and computing its composition. This method is both tedious and long. In the work that follows, the solution of this important part of the problem has been simplified.

Suppose that the nitric to be used is taken as  $X$ , and the sulphuric as  $Y$ , therefore, if it were desired to make 1000 units of this mixture, the amount of nitric to be used is represented by the ratio

$$X_{1000} = \left( \frac{X}{X + Y} \right) 1000$$

and the sulphuric by the ratio

$$Y_{1000} = \left( \frac{Y}{X + Y} \right) 1000$$

Substituting the values of  $X$  and  $Y$  from equations 8 and 9

$$X_{1000} = \frac{\left( \frac{C}{AP_n - 1} \right) 1000}{\frac{C}{AP_n - 1} + \frac{C}{AP_n - 1} - H} = \frac{\left( \frac{C}{AP_n - 1} \right) 1000}{\frac{TC + C - H(AP_n - 1)}{T(AP_n - 1)}} = \frac{(TC)1000}{(T + 1)C - H(AP_n - 1)} \quad (10)$$

applying the same process.

$$Y_{1000} = \frac{[C - H(AP_n - 1)]}{(T + 1)C - H(AP_n - 1)} \quad (11)$$

Now on to the assumption that  $X_{1000} + Y_{1000} = 1000$ , it will only be necessary to calculate one of the expressions and deduct the others by subtracting from 1000.

In order to simplify calculations allow for  $P_n$  constant variations and compute the resulting differences for

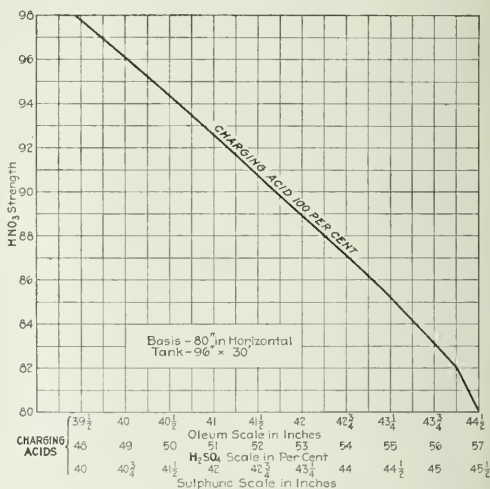


CHART II. CHART FOR MAKING FORTIFYING ACID WITH 104 PER CENT OLEUM OR 95 PER CENT  $\text{H}_2\text{SO}_4$

$H(AP_n - 1)$  when  $P_n$  takes the values  $P_n, P_{n_1}, P_{n_2}, \dots$  as follows:

$$H(AP_{n_1} - 1) - H(AP_{n_0} - 1) = HAP_{n_1} - H - HAP_{n_0} + H = (P_{n_1} - P_{n_0})HA$$

consequently if  $V_1, V_2, \dots$  are the different values for  $H(AP_n - 1)$  we have

$$V_0 = H(AP_{n_0} - 1);$$

$$V_1 = H(AP_{n_0} - 1) + HA(P_{n_1} - P_{n_0});$$

$$V_2 = V_1 + HA(P_{n_2} - P_{n_0});$$

$$V_3 = V_2 + HA(P_{n_3} - P_{n_0});$$

$$V_n = V_{n-1} + HA(P_{n_1} - P_{n_0}).$$

The values for  $X_{1000}$  and  $Y_{1000}$  computed from equation 10 are given in the following table and have been used for plotting the curve, Chart II, for the making of fortifying acids.



| $P_n$ | $X_{1000}$ | $Y_{1000}$ |
|-------|------------|------------|
| 0.80  | 42.83      | 57.17      |
| 0.82  | 43.69      | 56.31      |
| 0.84  | 44.60      | 55.40      |
| 0.86  | 45.55      | 54.45      |
| 0.88  | 46.54      | 53.46      |
| 0.90  | 47.58      | 52.42      |
| 0.92  | 48.66      | 51.34      |
| 0.94  | 49.79      | 50.21      |
| 0.96  | 50.98      | 49.02      |
| 0.98  | 52.22      | 47.78      |

To simplify drawing of curve even figures have been assumed in some instances.

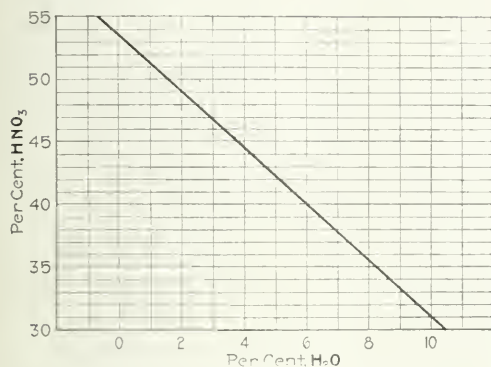


CHART III. FORTIFYING ACID CURVE

For practical purposes when  $P_n$  changes from a value of 1.00, say 0.95 to 1.05, corrections are to be made as follows:

$P_n > 1$  correction equals  $-(P_n - 100)$ ;

$P_n < 1$  correction equals  $+(100 - P_n)$ .

Usually when doping a spent acid with fortifying acid the calculations are based on the water and nitric content. It is necessary, therefore, to have an exact relation existing between those components in the fortifying acid. This phase is developed as follows:

Equation 10 gives the amount in units of nitric acid of strength to make 1000 units of fortifying mixture, therefore the 100 per cent nitric acid contained in  $X$  units will be,

$P_n X$ , or according to equation 10,

$$P_n X_{1000} = \frac{P_n TC 1000}{(T+1)C - H(AP_n - 1)} - N \quad (12)$$

and the water per cent will be,

$$W = X_{1000} - N = \frac{(TC)1000 - (P_n TC)1000}{(T+1)C - H(AP_n - 1)} \quad (13)$$

Eliminating  $P_n$  in equations 12 and 13 we obtain,

$$N = \frac{(TC)1000}{(T+1)C - H(A-1)} - \frac{[(T+1)C - H]1000}{(T+1)C - H(A-1)} \cdot W \quad (14)$$

#### DERIVATION OF CHART III

Equation 14 is the locus of all fortifying acids that, with the spent acid considered, will make the nitrating mixed acids come within the specified limits in component strengths. Its form and degree are those of a straight line, very easy to plot. Take, for instance,

two points corresponding to the values  $W = 0$  and  $W = 100$ , then  $N = 533$  and 310 respectively. These two points are sufficient for plotting the straight line, Chart III.

This O.K. fortifying acid curve can also be constructed by another method. Let  $D_N$  and  $D_W$  be the differences in amounts of the nitric acid and water between the nitrating and the spent acids. Let  $N_F$ ,  $W_F$ ,  $N$  and  $W$  be the nitric acid and the water in 1000 lb. of fortifying acid and the nitrating acid respectively. Let  $F$  equal the amount of fortifying to be used in order to obtain in  $A_s$  units of spent acid the increase  $D_N$  in nitric and the decrease  $D_W$  in the water. Therefore,

$$D_W = \frac{(W - W_F)}{A_s} F \text{ and } D_N = \frac{(N_F - N)}{A_s} F$$

$$\frac{D_N}{D_W} = \frac{N_F - N}{W - W_F}; \text{ now if to } W_F \text{ the values } 0, 1, 2, \dots$$

be given we get the corresponding values for  $N_F$ . Since this equation is that of a straight line, two points are sufficient for constructing the curve.

#### CHART FOR MAKING NITRATING MIXES

Let the amount of spent acid used for fortification equal  $A_s$ , and the amount of fortifying acid necessary equal  $F$ ,  $W_S$  = the water in the spent acid and  $W_F$  = the water in the fortifying acid and  $W$  = the water in the nitrating acid, then we have,

$$A_s W_S + F W_F = (A_s + F) W = A_s W + F W.$$

Therefore,  $A_s(W_S - W) = F(W - W_F)$ , and finally,

$$W_S - W = F \frac{(W - W_F)}{A_s} \quad (15)$$

In this equation  $W_S - W$  expresses the difference in water to be obtained by the addition of fortifying acid of definite content  $W_F$ , consequently if we assign values to  $W_F$  of 0, 1, 2, ...,  $n$  we get in each case the equation of a straight line of the Form  $Y = aX$ , all having the same origin. Now if we give to  $A_s$  the particular value 1000,  $F$  will represent in each case the amount of fortifying acid to be used for each 1000 units of spent acid for getting the reduction in water equal to  $(W_S - W)$ . If instead of the water, we consider the nitric acid, we will realize that we ought to have an increase in the percentage of nitric and then the equation would become,

$$N - N_S = \frac{(N_F - N) F}{A_s} \quad (16)$$

and this equation has the same properties as equation 15.

The construction of the chart then follows.

Take a vertical axis upon which we will count the  $F$  values, give values to  $A_s$  equal 1000,  $W_F = 0, 1, 2, 3, \dots n$  and take  $(W_S - W) = 10$  construct on the left hand side the resulting radial straight lines.

Assigning to  $N_F$  values between 250 and 500 make  $(N - N_s) = 30$ , then construct the lines on the right hand side of the axis Chart IV. The accuracy of the chart depends on the scale used.

Several instances showing the simplicity of its uses will be developed.

First—Computation of the O.K. fortifying acid nec-

essary to make a nitrating mixed acid by fortifying spent acid. Take for instance,

Water in the spent acid, . . . 16.00 per cent  
 Water in the mixed acid, . . . 14.80 per cent  
 Water to be reduced, . . . . . 1.20 per cent  
 Water in the fortifying acid, 6.00 per cent

#### Procedure:

Follow the water line marked 6 per cent until intersection of the vertical line marked 1.20 per cent. From this point go horizontally until intersection of vertical axis at a point reading 14,000 (see Chart IV). This means that for each 1000 units of spent acid we shall add 140 units of fortifying acid. Regarding the nitric content, we assume that it will adjust itself automatically within the specified limits, since the fortifying acid used is an O.K. one.

#### Second—

Spent acid  $\left\{ \begin{array}{l} \text{H}_2\text{O} = 16.40 \text{ per cent} \\ \text{available HNO}_3 = 17.30 \text{ per cent} \end{array} \right.$   
 Mixed acid to be made  $\left\{ \begin{array}{l} \text{H}_2\text{O} = 15.10, \pm 0.05 \\ \text{HNO}_3 = 20.00, \pm 0.50 \end{array} \right.$   
 Fortifying acid to be used  $\left\{ \begin{array}{l} \text{H}_2\text{O} = 5.00 \\ \text{HNO}_3 = 44.00. \end{array} \right.$

Water is to be reduced 1.30, nitric to be increased 2.70 to 3.20 per cent.

Chart IV gives on the line 5 per cent and that corresponding to the water reduced 1.30 per cent, 13,500, or 135 fortifying acid units for 1000 units of spent acid. The increasing nitric acid will be taken according to the reading on the chart, upon the same line, 135 and line 44 per cent and equals 3.20 per cent. Then the resulting mixed acid should be

$\text{H}_2\text{O} = 16.40 - 1.30 = 15.10 \text{ per cent}$   
 $\text{HNO}_3 = 17.30 + 3.20 = 20.50 \text{ per cent}$

Third—To determine the percentage composition of water and nitric in the spent acids.

Fortifying acid used in making mixed acid,

$\text{H}_2\text{O} = 4.50 \text{ per cent}$   
 $\text{HNO}_3 = 44.50 \text{ per cent}$

Mixes obtained with this fortifying analyzed as follows:

| No. of Mines | Per Cent $\text{H}_2\text{O}$ | Per Cent $\text{HNO}_3$ |
|--------------|-------------------------------|-------------------------|
| 1            | 15.15                         | 20.30                   |
| 2            | 15.20                         | 20.26                   |
| 3            | 15.18                         | 20.46                   |
| 4            | 15.12                         | 20.20                   |
| 5            | 15.22                         | 20.35                   |
| Mean         | 15.17                         | 20.31                   |

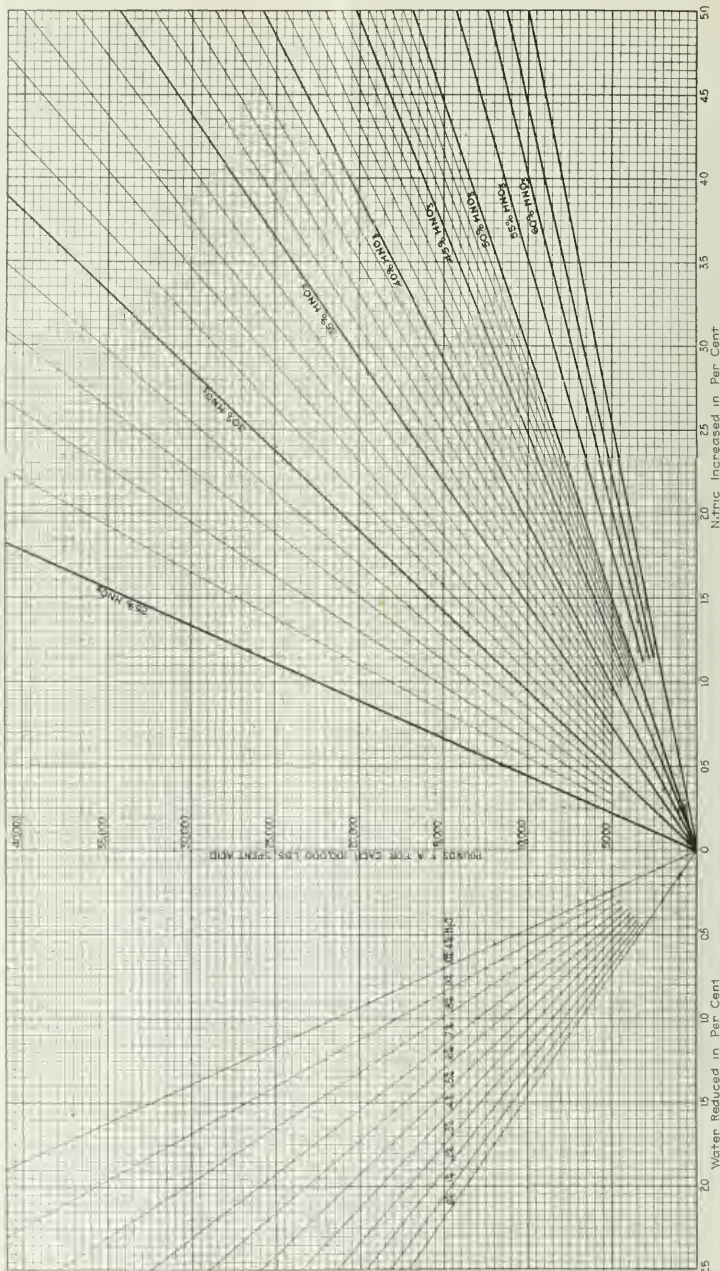


CHART IV. CHART FOR MAKING MIXED ACIDS

Ratio between spent acid and fortifying acid used,

$\frac{A}{F} = \frac{12}{100}$  then Chart IV gives,

Water reduced = 1.22 per cent;  
 Nitric increased = 2.90 per cent;  
 consequently the spent acid had,  
 $\text{H}_2\text{O} = 15.17 + 1.22 = 16.39 \text{ per cent.}$

Fourth—Use of two fortifying acids of different composition, one strong in "nitric" and the other weak.

|                        |                                                                                                                              |
|------------------------|------------------------------------------------------------------------------------------------------------------------------|
| Strong Fortifying Acid | $\left\{ \begin{array}{l} \text{H}_2\text{O} = 7 \text{ per cent} \\ \text{HNO}_3 = 45 \text{ per cent} \end{array} \right.$ |
|                        | $\left\{ \begin{array}{l} \text{H}_2\text{O} = 5 \text{ per cent} \\ \text{HNO}_3 = 40 \text{ per cent} \end{array} \right.$ |
| Weak Fortifying Acid   |                                                                                                                              |

We want to reduce the water by 1.20 per cent and increase the nitric 2.90 per cent. Applying the chart for both separately we have:

Strong—Water reduced 1.20 per cent, nitric increase 3.83 per cent;

Weak—Water reduced 1.20 per cent, nitric increase 2.43 per cent.

Difference in "plus" =  $3.83 - 2.90 = +0.93$  per cent in the first.

Difference in "minus" =  $2.90 - 2.43 = -0.47$  per cent in the second, according with those differences we can see that by using two parts of the weak fortifying acid we can balance the surplus in nitric made by using one part of the strong, or in other words, we can reduce the water 0.40 per cent by using 5250 pounds of the fortifying acid with 7 per cent water (see Chart IV) and 0.80 per cent by using 8250 pounds of the fortifying acid with 5 per cent water.

Some of the mixes made up in the mixing house require small corrections to bring them within the fixed limits of nitric acid and water content respectively. These corrections can also be computed with the aid of Chart IV.

Let the fortifying acid in use be  $W_F$  per cent  $\text{H}_2\text{O}$ . Take on the central scale Chart IV the point marked 10,000; the intersections along this 10,000 line with the water straight lines will give in each case the effect obtained by the addition of that amount of fortifying acid in 100,000 units of spent acid; now if in each case we place the decimal one place to the left we will get the effect of a thousand units in 100,000 units of mixed acid. Take, for instance, water = 5 per cent and read on the intersection of this line with the 10,000 line the reading is 0.96. Make the decimal one place to the left and we get the correction .096 per cent. The correction computed by other methods for mixer containing 14.50 per cent to 15.50 per cent water is between 0.094 and 0.10 of 1 per cent. Several arrangements can be used for definite amounts of mixed acid other than 100,000 pounds. We will take two instances. First, horizontal tanks containing 150,000 pounds mixed acid, and, second, vertical tanks containing 300,000 pounds. In the first case the effect obtained with the addition of 1000 pounds of fortifying acid on 100,000 pounds mixed is in the ratio of  $\frac{100}{150} = 0.67$ ; consequently if we mark the line corresponding to 6700 pounds on the chart we will obtain the corrections by direct reading without further calculation. In the second case there is always a definite ratio between the "dip" in inches and the content in pounds, so, assuming that one inch represents 2300 pounds mixed acid, we can compute the effect of one inch fortifying acid as follows:

Correction obtained by 1000 pounds fortifying acid on 100,000 pounds mixed = C.

Correction obtained by 2300 lb. fortifying and in 300,000 is equal to 0.77 C, development as follows: correction obtained by adding 1000 lb. to 100,000 lb. = C.

The effect produced by the same addition to 300,000 lb. is equal to  $\frac{C}{3}$  and, therefore when the addition is

2300 lb. the correction becomes  $\frac{2.3 \times C}{3} = 0.77C$ .

Consequently you draw a line on the line 7.700 pounds and read, placing decimal one point to the left and get the corrections without any further calculations.

Nitro, West Virginia.

## Safe Load on I-Beam by Rule of Thumb

BY JOHN S. CARPENTER

WHEN installing new machinery or taking out old, it is often desirable to use a block and tackle. Such rigging must be attached to beams, which usually may be found around power plants and may be arranged so that they are directly over the load. In a case of this kind it is desirable to know just what safe load may be put on the beam. A rule of thumb that will give this information is as follows:

Multiply the weight per foot of the I-beam by the depth in inches and divide the product by the span in feet. The result is the safe load in thousands of pounds for a uniformly distributed load. For a single load in the center of the span, take half the foregoing result.

To the writer, who has always figured beams by the usual bending-moment formulae, this rule did not sound right. It seemed too good to be true. So he determined to prove it to his own satisfaction. Let

- $W$  = Safe uniform load in pounds;
- $L$  = Span in feet;
- $S$  = Section modulus;
- $s$  = Safe stress, 16,000 lb. per sq.in.;
- $w$  = Weight of beam per foot;
- $d$  = Depth of beam in inches.

According to the rule, then,  $W = \frac{1000wd}{L}$ . But

for a beam uniformly loaded, the safe load is  $W = \frac{8Ss}{12L}$ .

Therefore, it follows that  $\frac{8Ss}{12L} = \frac{1000wd}{L}$  or  $8Ss = 12,000wd$ , from which, letting  $s = 16,000$ , it is found that  $S = 0.1067wd$ . In other words, the section modulus is equal to the product of the weight of the beam per foot, the depth in inches and a constant 0.1067. That this is approximately true may be ascertained by comparison with any steel manufacturer's catalog.

There were cases in which the writer did not know the weight per foot of the beam in question and so could not apply the rule. So he made up a table, as follows:

| Depth of Beam, in. | Value of Constant | Depth of Beam, in. | Value of Constant |
|--------------------|-------------------|--------------------|-------------------|
| 3                  | 16,500            | 10                 | 256,000           |
| 4                  | 30,000            | 12                 | 375,000           |
| 5                  | 43,750            | 15                 | 630,000           |
| 6                  | 73,500            | 18                 | 990,000           |
| 7                  | 105,000           | 20                 | 1,300,000         |
| 8                  | 144,000           | 24                 | 1,920,000         |
| 9                  | 189,000           |                    |                   |

To use the table in applying the rule, divide the constant opposite the depth of beam by twice the span in feet. The result is the safe load hung in the center of the span. For channels the safe load is half that for an I-beam of the same size. The safe loads found by the foregoing constants will differ by only 5 or 6 per cent. from the actual safe loads.—Power, Sept. 24.



# Collective and Preferential Flotation

A Description Having Special Reference to the Bradford Process—Factors Involved in Flotation Processes—Preferential Wetting of Sulphides by Sulphur Dioxide—Use of Mechanical Beaters—Laboratory Control of Process

By GUY C. RIDDELL

Consulting Engineer, United States Tariff Commission, Washington, D. C.

**F**LOTATION is at the moment a much discussed branch of metallurgy. Indiscriminate or collective flotation, viz., the concentration of sulphides irrespective of kind into one mixed product, is generally employed the world over. Preferential flotation, viz., the separation of one class of sulphides from another into independent products, has attracted much attention of late, but is not yet generally applied in practice. This selective flotation is widely used in Australia, but there are a few instances only in which differential flotation is practiced successfully in the United States.

Though the principle of flotation dates back a number of years, it was not until sixteen years ago (1902) that active steps were taken in Broken Hill, Australia, to make practical use of the flotation property naturally possessed by mineral sulphides. Once demonstrated as a practical concentrating method, however, mine managers were quick to grasp the advantages offered by this method of treatment, and as a result various processes for the recovery of sulphides by flotation were speedily developed and used. It is curious to note that despite the great advantages of flotation, even the best of these processes are in some places still looked upon as a necessary evil. One frequently hears it referred to as a very simple but elusive method of treatment. This is undoubtedly due in many instances to a lack of appreciation of the value of testing and laboratory control.

Flotation calls for rather more special experience and skill in practical operation than do most metallurgical processes. Certain conditions peculiar to and varying with each particular ore have to be more or less rigidly maintained in the application of every form of the process. While it is true that most good metallurgy starts in the laboratory, in flotation particularly it is an axiom that the most suitable operating conditions should first be worked out in the research laboratory and subsequently passed on to the operating department. Many mistakes are made that result in the loss of values in wholesale fashion by making alterations in the running plant without knowing in advance the effect of such alterations.

## THE FACTORS INVOLVED IN FLOTATION PROCESSES

Generally speaking, there exists a more or less critical balance between the various essentials in all flotation processes. The nature and degree of crushing, the proportion of coarse and fine in the crushed ore, the density of the pulp, temperature and quantity of acid additions, the degree of agitation and (or) aeration, the kind and quality of oil or emulsifying agent used and the rate of settling of the pulp are the principal factors which require careful study. A

complete series of laboratory tests should be made to ascertain the effect of varying one or more of these factors in the case of each independent ore. Unless the sulphides are very easily floatable slight changes in the balance of any of the above conditions will often upset recoveries substantially. Fortunately the margin of latitude in the critical variables is sufficiently great in the case of most ores to leave the treatment thoroughly practical. At the same time the conditions cannot be too freely tampered with if good results are to be maintained.

It has been in a large measure due to this special requirement on the part of flotation processes that they are not applied except where ordinary gravity concentration fails to accomplish results. It also explains why flotation is looked upon with suspicion by the mill man. One finds very few instances where flotation is employed, as it should be, to replace inefficient work done by gravity methods of concentration. In other words, flotation is often tacked on only as an appendage to gravity concentration. This fact explains why some plants are only at the flotation introduction stage today, when they ought to have been reaping a rich harvest a decade ago.

## WETTED AND NON-WETTED SULPHIDES

Just as collective flotation methods have been in the past arrested in their development, so also are preferential flotation methods now running the gantlet. And since these latter methods demand a still more careful control as compared with collective flotation, one may suppose that they will take longer to come into their own. And yet it is possible that this may not be so, by reason of the fact that there exist many deposits of complex ores which are not amenable to the ordinary methods of treatment. These "diseased" ores have so far remained a locked up potential asset; with the advent of successful preferential methods of treatment they will be resolved into valuable products.

Any preferential process destined to full success must have as its basis some positive means of wetting one or more of the mineral sulphide particles, while leaving another temporarily immune to wetting. After such a treatment the non-wetted class of sulphides can then be floated by themselves, leaving the wetted sulphides submerged. Moreover, it is necessary in such a process that the wetting of the particular sulphide must be of such a nature that its air film can be restored when required, so that after the complete removal of the non-wetted class of sulphides the wetted sulphide can subsequently also be floated from the gangue.

Leslie Bradford, one of Australia's leading metal-

lurgists, has discovered such a positive direct preferential method of flotation, in the  $\text{SO}_2$  process patented by him in Australia four years ago, which has been in practical operation for the past three years in Broken Hill. The process is a very simple one and it seems destined to come into prominence, as it offers a means for the separation of lead, copper and pyrite, together with the silver and gold, from the blende—the solution of a vexing problem at many a refractory ore deposit.

#### PULP ACIDIFIED WITH SULPHUR DIOXIDE

The preferential effect in this operation is obtained by the addition to the pulp of either hyposulphite of soda and sulphuric acid, or sulphur dioxide gas. The  $\text{SO}_2$  gas is produced from burning sulphur and is allowed to bubble into a small storage box at the head of the plant. In some cases  $\text{SO}_2$  gas produced from roasting operations answers. In addition to adding the sulphur dioxide at this head box it is sometimes necessary to provide pipes for the admission of the gas into the agitators connected with the flotation vessel. It is found that under these conditions the galena and pyrite float by themselves and that the blende is wetted and refuses to float.

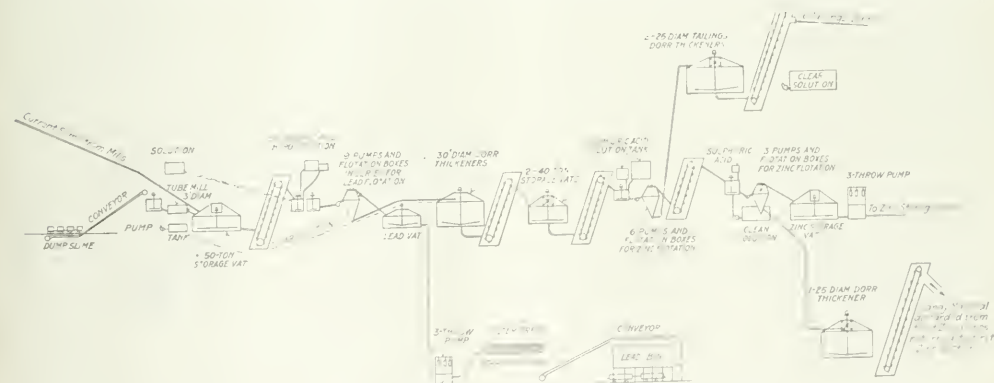
This preferential action is explained as follows: It can be said briefly that all flotation of sulphide ores is dependent on the presence about the particle of a gaseous envelope. Mr. Bradford solved the problem of removing the gaseous envelope from some sulphides without removing it from others. Theory suggested and experience proved that such a result could be accomplished by the action of a suitable reducing agent contained in

The fact that the blende particles are not changed chemically is of great practical importance, since those particles are not rendered permanently incapable of flotation, but only temporarily immune thereto. So long as they lie in this reducing solution they will remain wetted, but as soon as transferred from that solution and aerated (or the solution oxidized and aerated) they immediately regain their gaseous envelope and exhibit the same flotation phenomena as at first.

Having removed the galena completely, the blende is floated by itself from the gangue by either dissipating the small quantity of  $\text{SO}_2$  gas by steam or by transferring the delead pulp to a separate set of flotation boxes after the removal of the bulk of the sulphurous liquor, which is returned to the deleading section. These methods are equally successful.

The Junction North Silver Mining Co., Broken Hill, employs the former method. This company introduced the  $\text{SO}_2$  preferential process some three years ago and is quite satisfied with results. It has been in continuous operation at this mine since its introduction. It is here being used in a minerals separation impeller type of apparatus, the emulsifying agent being eucalyptus oil. About 2500 tons weekly are going through this plant.

The accompanying flow sheet shows the slimes plant in which the process is being used at the Broken Hill Proprietary Co.'s mine in Australia. This is self-explanatory. A notable feature is that no oil or other organic emulsifying agent whatsoever is employed in this plant. For some time sodium sulphate or nitre cake (from five to seven lb. per ton of slime) was added to promote emulsification of the pulp, but this is found



FLOW SHEET OF SLIME PLANT

the floating medium, this agent being one which removes the gaseous envelope without chemically changing the ore. Tests and experiments proved that sulphur dioxide gas dissolved in the liquid reduces and removes the gaseous envelope from the blende particles, without affecting the film which surrounds the pyrite or galena particles; wherefore the subsequent flotation treatment (which may conveniently be, and preferably is, performed simultaneously in the same liquid) removes the pyrite and galena (the non-wetted particles), while the sulphide of zinc (which is wetted, owing to the solution and removal of its protecting gaseous envelope) falls to the bottom along with the gangue.

not to be necessary and is no longer used. No hyposulphite of soda is now added to the pulp, sulphur dioxide gas alone being employed. The quantity of  $\text{SO}_2$  used is equivalent to  $1\frac{1}{2}$  lb. sulphur per ton slimes treated. Excellent results are being obtained from this plant, which is handling some 3000 tons per week.

#### THE USE OF MECHANICAL BEATERS

Broken Hill flotation practice in general has a distinct leaning toward the more intensive agitation methods and apparatus. There was a period at Broken Hill when it was thought that mechanical aëration (beating of air into pulp by churning) was not a necessity, but all

companies have eventually gone over to mechanical agitation of a very positive order. At the B. H. P. mill, in fact, an enclosed centrifugal pump agitator is in use—patented by Leslie Bradford in 1911—which agitates and churns the pulp under pressure. The resulting aëration and gasification is intensive and thorough, and the subsequent separation of metallic sulphides in the spitzkasten into which the centrifugal pump delivers is accomplished entirely without the use of oil in the flotation medium.

Now that  $\text{SO}_2$  preferential flotation has passed through the experimental stages and definitely taken its place among the approved processes, further extension of its application is at hand. Up to the present time the treatment has been limited to slimes, but since it effects a preferential flotation in acidulated solutions and is not upset by additions of varying quantities of oils or other frothing agents, it follows that coarse sand of floatable size can be as efficiently treated as the slimes. This is an important feature, and one that is destined to increase the scope of flotation considerably.

#### FLOTATION SHOULD NOT BE A MERE GRAVITY PROCESS FINISHER

Heretofore the treatment adopted generally in Australia has been to subject the slimes resulting from gravity concentration to preferential flotation methods in a separate flotation unit. The Broken Hill ores at center of lode carry a heavy rhodonite content, and the blende is not readily separable by gravity methods. Crude ores run 15 to 16 per cent Pb, 13 to 16 per cent Zn and 12 to 13 oz. Ag. The pulp is de-leaded to the ultimate degree by gravity methods and the de-leaded material then floated for the recovery of the blende from the gangue. I will not say that this practice is a poor one, but it is, in the opinion of some of the Broken Hill metallurgists themselves, open to criticism for the following reasons: (1) It necessitates a costly plant installation; (2) de-leading of fine grit is only partial; (3) flotation concentrates are low in grade for this reason and have to be tabled; (4) stratification of float concentrates yields indifferent results; (5) grade of zinc concentrates obtained after all these successive treatments is low; (6) recoveries of both lead and zinc are considerably lower than those obtained by preferential flotation; (7) flotation of sand and slimes in two separate flotation units requires additional plant, and recoveries are not as good as when admixed; (8) handling of slime products by themselves is expensive.

The rational treatment would be to stop concentration by gravity methods on all material as soon as it has been crushed down and reduced to floatable size, and to send the whole of the mill flow from this point direct to the preferential flotation plant. The presence of the slimes would assist the flotation of the coarser mineral, and the sand would assist the rate of settling of the slimes. The concentrates resulting from preferential flotation would call for no special means of handling. Recoveries obtained by this method of treatment would be much better, and costs would be lower. The grade of both lead and zinc concentrates would be considerably enhanced.

In fact, if an ore has to be crushed down to floatable size before concentration becomes possible, there is no reason why gravity concentration in such a case should

not be entirely dispensed with to advantage. Experiments and tests made by the Bradford process on crude ores have yielded excellent results. Mill flows after the coarse Wilfley tables, i.e. both sand and slime together, have also been tested and have been found in all cases to yield excellent recoveries and high-grade products.

The  $\text{SO}_2$  process differs from other preferential processes in that it offers a positive means of wetting the blende. It is much more elastic than other preferential processes, and, unlike these, which are only applicable to the treatment of slimes or impalpably fine mill products, it can successfully float comparatively coarse galena particles.

Experimental tests have been made on several hundred tons of pyrite-galena-zinc ores outside the Australian field, representing the complex ores of Tasmania, India, Canada, Mexico and the United States, and in every instance the  $\text{SO}_2$  treatment in the hands of an operator experienced in the process has effected an excellent separation of the lead, copper and pyrite from the blende. The ores on which the process has been tested are notably those belonging to that class of intimately mixed and difficultly separable ores known as "diseased." The complex sulphide ores of the Rosebery-Hercules mines in Tasmania containing blende, galena and pyrite gave a zinc concentrate containing up to 58 per cent Zn, with recoveries from 80 to 85 per cent.

#### THE FEATURES OF A PROPER LABORATORY CONTROL

The laboratory testing of ores by the  $\text{SO}_2$  treatment requires a considerable amount of skill and patience until the proper regulation of sulphur dioxide, temperature, sulphuric acid, density of pulp, degree of agitation, rate of settling, etc., is attained. Several instances are recorded where preliminary and even repeated tests in the hands of operators who were skilled in general flotation methods but inexperienced in the  $\text{SO}_2$  treatment were of indifferent success, these same ores yielding splendid results, however, when handled by  $\text{SO}_2$  men. It has been fully demonstrated in the several mills using the process at Broken Hill that no special skill is required in the large size plant to keep  $\text{SO}_2$  additions adjusted to suit conditions. The bulk concentrates, both zinc and lead, being turned out at Broken Hill remove any doubt that these remarks on the laboratory testing of the process might convey as to its being too neat to be practical.

There are certain points that receive careful attention at Broken Hill, as follows:

1. Density of pulp on lead section. This should not exceed 27 per cent solid by weight. Higher pulps do not yield maximum grade of lead concentrate, and the zinc concentrate in turn suffers.

2. Temperature of pulp at head of lead section. This is kept below 90 deg. F. At temperatures above this the zinc shows tendency to float.

3. Acidity of pulp on lead section. This is not allowed to go much above 0.03 per cent. Higher acidity than this acts much as does too much temperature. If the solution, however, becomes neutral, lead concentrate falls off in grade because of gangue passing over with it. Both temperature and acidity are readily controlled in practice, and results are uniform and regular.

4.  $\text{SO}_2$  pipes must not become choked. The lead con-



centrates remain clean only as long as the  $\text{SO}_2$  feed is properly delivered, and a choked pipe promptly shows itself in the color of the lead flowing from the spitzkasten. The cause of this trouble is volatilized sulphur due to excessive heat in the sulphur-burners which supply the  $\text{SO}_2$ . It is checked by having a few holes in the 3-inch  $\text{SO}_2$  main which can be opened when the temperature of the burner rises unduly, the air entering through these checking the draft and combustion at the burner.

$\text{SO}_2$  selective flotation on Broken Hill ore is producing and maintaining a notably high grade of zinc concentrates (viz., 50 per cent), with lead concentrates averaging 63 per cent. It is the only preferential process so far made known which operates in the presence of acid. This is a great advantage in that coarser size lead particles can be recovered by preferential flotation without trouble.

The Bradford process is now being worked on three companies at Broken Hill, the aggregate tonnage being put through amounting to approximately 8000 tons weekly. Its extensive adoption in Australia has come about after a number of years of more or less successful trials with various other preferential treatments that have had a vogue at Broken Hill but which have lacked the positive dependable action of the  $\text{SO}_2$  method.

## Application of Zinc in the Building Trades

BY J. A. SINGMASTER

A GREAT many persons associate the word "zinc" with a cast rod commonly used in electrical batteries. This product is brittle and crystalline and can be readily broken. They do not know that zinc is rolled and that in this shape it is remarkably ductile and tough. It is extremely resistant to atmospheric corrosion and in view of these qualities has found a tremendous application in the building trades in Europe. It displaces the more expensive metals, such as copper and lead, for roofing, flashing, spouting and guttering, with no sacrifice of durability and at considerable saving in first cost. Tin and terne-plate and galvanized iron, which we so commonly use for exterior work, are usually cheaper in first cost, but when length of life, cost of painting and replacement are taken into account they are more expensive for permanent construction.

Rolled zinc is now largely used in this country in the manufacture of so-called "leaded" glass, where rolled zinc sections of any desired shape support the glass. This zinc often is given the lead finish desired for architectural effect, and is much stiffer and more durable than the metal it has replaced. It is also made in the shape of shingles or tile, which can be treated to give most artistic effects, possessing the great advantage of permanence and unbreakability. Spouting and guttering of zinc have artistic possibilities, and in addition the owner will not be able to poke his finger through the leaders on his house at the end of three or four years, nor will he have to paint them continually.

Rolled zinc is also used largely in this country for weather-strips where permanency and ultimate cost are a consideration. It has, of course, been used for years

in fastening glass in wooden frames in the shape of the familiar glaziers' "points."

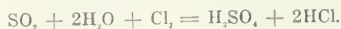
The use of zinc demands a certain familiarity with the metal, which can be had with a little practice, and the selection of the proper quality of material for any given application. Zinc can be hard, medium hard and soft rolled. Hard rolled zinc would not stand bending for seam work, while soft metal can be drawn, bent and spun into the greatest variety of shapes. One of the great drawbacks to its use in the past has been the lack of appreciation of this point. No one using brass sheet would think of ordering it without specifying the kind of brass, yet ordinary zinc sheet is expected, when bought from a dealer, to meet any and every use, without due consideration of its physical properties.

A popular misapprehension exists regarding the soldering of zinc, numerous statements having appeared regarding the solution of this supposedly difficult problem. On the contrary, zinc is one of the easiest soldered metals. Any one desiring to inspect a soldered joint can do so by removing the paper or cardboard cover from an ordinary dry battery cell, such as is used for operating doorbells, all dry battery cells being contained in soldered zinc cans.

A large expansion in the use of zinc in the building trades is certain to come here as it has come in Europe. Those who first take advantage of this development and familiarize themselves with the possibilities and uses of zinc will reap the benefits which have repeatedly come to those in every branch of industry who have studied and applied foreign improvements to American practice.

New Jersey Zinc Co.,  
New York, N. Y.

**Detinning Scrap.**—O. K. ZWINGENBERGER of Tompkinsville, N. Y., notes that in the process of detinning scrap small traces of water left on the metal or in the chlorine gas are very detrimental to the yield of tin tetrachloride. It is very difficult to remove the last traces of moisture in the reacting substances. Its presence causes the formation of crystalline tin tetrachloride which covers the metal like snow, absorbs liquid  $\text{SnCl}_4$ , and prevents the effective penetration of chlorine gas to unaffected surfaces. Thus it reduces the recovery of tin, and at the same time wastes chlorine, especially as water vapor induces the formation of iron chlorides. The inventor absorbs these traces of water by adding 5 per cent of the quantitative amount of sulphur dioxide according to the following reaction:



As  $\text{H}_2\text{SO}_4$  of greater concentration than 66 deg. B. does not dissolve iron and dry  $\text{HCl}$  is also inactive, the formation of stannic chloride is not hindered. The sulphur dioxide and the chlorine are mixed in a mixing chamber or tower at such a rate that the above reaction shall be completed some time before the recovery of the tin is completed. The rate of  $\text{SO}_2$  admission is also greater at first in order to take care of the water contained in the dried scrap. The reaction takes place in the detinning pot to a large degree and does not interfere with the formation of tin chloride, in fact by the removal of water vapor it prevents the retention of crystalline tin compounds in the treated mass. (1,260,119; Mar. 19, 1918.)

## Fusibility of Coal Ash From West Virginia Coals\*

The Method of Preparing Ash for Fusion Tests and Determining Initial Softening Temperature and Interval of Fusion—A Summary of Tests on West Virginia Coals, Including the Monongahela, Conemaugh, Allegheny and Pottsville Series

By WALTER A. SELVIG

INFORMATION concerning the fusibility of coal ash has become of considerable interest to the consumer of coal during the last few years, principally in connection with the troublesome formation of clinker which results from the melting of the ash constituents of the coal when subjected to heat.

The growing interest for such data has led the Bureau of Mines to make a general survey of the "fusing" or "softening" temperatures of the ash from well known American coals. It is hoped that this information when used together with the large number of coal analyses made available by the publications of the Bureau of Mines<sup>1</sup> will be of help to the consumer of coal in comparing the different coals and in the selection of the coal best adapted for his purpose.

This paper gives the results obtained for West Virginia coals, among which are found some of the purest fuels of the country.

The method employed for the fusibility tests was the standard gas furnace method<sup>2</sup> of the bureau. In order better to interpret the results given in the table of fusibility this method is briefly summarized here.

### PREPARATION OF CONES

The coal samples are ground to 60 mesh, with crusher, rolls and ball mill. This 60-mesh material is then placed in shallow fire-clay roasting dishes and completely ashed in a muffle furnace at a temperature of 800 deg. C. to 900 deg. C.

The resulting ash is ground in an agate mortar to pass a 200-mesh sieve. To make sure that the coal has been completely ashed, the ash after grinding is placed in fused silica capsules and ignited at 800 deg. C. for two hours, a current of oxygen gas passing through the furnace during the ignition period. This ignition is made to insure complete and uniform oxidation of the ash.

A portion of the ash is transferred to an agate mortar, moistened with a 10 per cent dextrin solution and worked into a plastic mass with a spatula. The ash is then molded into solid triangular pyramids  $\frac{3}{4}$  inch high and  $\frac{1}{4}$  inch wide at the side of the base. These cones are removed from the brass cone mold, dried and mounted in a vertical position in a refractory

base made up of a mixture of two parts of kaolin to one part of calcined alumina. Usually five cones are mounted in the same base. The base with the cones is dried carefully over the hot plate until all water is driven off, then the dextrin is burned out of the cones by igniting the mounted cones in a muffle furnace at a dull red heat, after which the cones are ready for use.

### DESCRIPTION AND OPERATION OF FURNACE

The furnace used was the No. 3 melter's furnace (Fig. 1) of the American Gas Furnace Co., natural gas and air pressure of from 2 to 3 pounds to the square inch being used. The cones, supported by a suitable mounting, are placed within a covered fire-clay crucible in the furnace. A 2-in. hole is drilled through the furnace jacket and fire-clay crucible for observation purposes, a fused silica tube carrying a thin glass window being placed in the observation hole. At right angles to the observation hole a 4-in. hole is drilled through the furnace and crucible. Through this hole a platinum-rhodium thermo-couple, protected by a glazed porcelain tube, is inserted. By proper adjustment of the gas and air a reducing atmosphere is maintained within the furnace this being accomplished by using the minimum amount of air necessary to attain the desired temperature. Under these conditions, the iron in the ash is

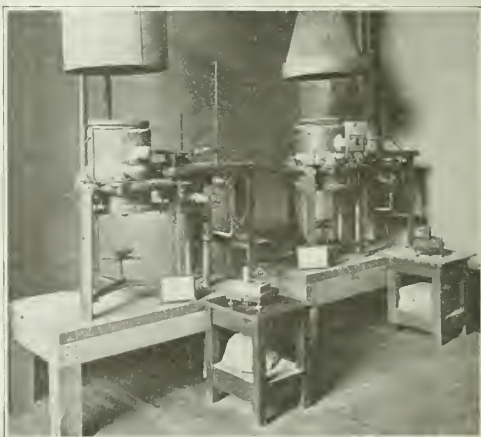


FIG. 1. NO. 3 MELTER'S FURNACE AND ACCESSORIES

reduced to the ferrous state, which condition gives the lowest melting points and therefore gives the lowest temperature at which clinkering may result. The temperature is gradually increased to 800 deg. C., when the rate is slowed down to not less than 5 deg. C. nor more

\*Published with the permission of the Director of the U. S. Bureau of Mines.  
1. Lord, N. W., and others: Analyses of coals in the United States, with descriptions of mine and field samples collected between July 1, 1901, and June 30, 1910: Bull. 22, Bureau of Mines, 1913, 1200 pp. (In two parts.)  
2. Fieldner, A. C., and others: Analyses of mine and car samples collected in the fiscal years 1911 to 1913: Bull. 85, Bureau of Mines, 1914, 444 pp.  
3. Fieldner, A. C., and others: Analyses of mine and car samples collected in the fiscal years 1913 to 1916: Bull. 123, Bureau of Mines, 1917, 456 pp.  
4. For detailed description of this method and discussion of the influence of various factors on the fusibility of coal ash, see Fieldner, A. C., and others: Field, A. L.: The fusibility of coal ash: Bull. 129, Bureau of Mines, 1918, 146 pp. (In press.)

than 10 deg. C. per minute, this rate being maintained until the end of the test, when a maximum temperature of 1500 deg. C., or 2732 deg. F., is attained.

In some instances with coal ash of an especially refractory nature the cones which did not fuse at the highest temperature attained in the gas furnace, were further heated in a molybdenum wire resistance furnace<sup>1</sup> in an atmosphere of hydrogen gas. Under these conditions temperatures as high as 3010 deg. F. and in some instances slightly higher were attained. However, a coal whose ash fuses above 2730 deg. F. should give very little trouble due to clinker formation.

The temperature readings taken were:

(1) *The initial deformation temperature.* The temperature at which the first rounding or bending of the apex of the cone takes place as shown in cone 1 of Fig. 2.

(2) *The softening temperature.* The temperature at which the cone has fused down to a spherical lump as shown in cones 2 and 3 of Fig. 2.

Only the average softening temperature is reported, together with the softening interval, which is the difference in degrees between the softening temperature and the initial deformation temperature.

#### INTERPRETATION OF FUSIBILITY TABLE

According to the West Virginia Geological Survey there are 102 known coal beds in West Virginia, of which 52 are minable. The table contains samples representing nearly one-half of these minable beds, the beds listed being among the most important in the state.

The various beds are arranged according to their geological succession, from information supplied by courtesy of the West Virginia Geological Survey together with information taken from the *Keystone Coal Catalog*,<sup>2</sup> the uppermost coal beds being listed first. The succession of coal beds, with the average softening temperatures, softening interval, ash per cent and sulphur content, is as follows:

|                                                            | Average<br>Softening-<br>Temper-<br>ature,<br>Deg. | Soft-<br>ening<br>Inter-<br>val,<br>Deg. | Ash,<br>Per<br>Cent. | Sulphur,<br>Per<br>Cent. |
|------------------------------------------------------------|----------------------------------------------------|------------------------------------------|----------------------|--------------------------|
| Monongahela Series:                                        |                                                    |                                          |                      |                          |
| Sewickley Bed                                              | 2080                                               | 80                                       | 9.61                 | 3.99                     |
| Redstone Bed                                               | 2120                                               | 150                                      | 6.96                 | 1.92                     |
| Pittsburgh Bed                                             | 2170                                               | 90                                       | 7.20                 | 2.24                     |
| Conemaugh Series:                                          |                                                    |                                          |                      |                          |
| Mahoning Bed                                               | 2160                                               | 130                                      | 5.62                 | 1.89                     |
| Allegheny Series:                                          |                                                    |                                          |                      |                          |
| Upper Freeport Bed                                         | 2190                                               | 220                                      | 6.17                 | 1.97                     |
| Lower Freeport Bed                                         | 2090                                               | 110                                      | 9.84                 | 3.14                     |
| Middle Kittanning Bed                                      | 2110                                               | 110                                      | 10.93                | 4.06                     |
| Lower Kittanning Bed                                       | 2660                                               | 140                                      | 7.64                 | 1.76                     |
| Pottsville Series:                                         |                                                    |                                          |                      |                          |
| Kanawha Group:                                             |                                                    |                                          |                      |                          |
| Coalbed (Buffalo Creek)                                    | 2960                                               | 80                                       | 8.80                 | 0.76                     |
| Winifrede (Black Band)                                     | 2970                                               | 170                                      | 8.44                 | 0.83                     |
| Cedar Grove (Thick)                                        | 2610                                               | 160                                      | 5.83                 | 1.07                     |
| No. 2 Gas (Capefield Creek, Island Creek, Upper War Eagle) | 2750                                               | 120                                      | 5.86                 | 0.88                     |
| Eagle                                                      | 2940                                               | 150                                      | 4.40                 | 0.77                     |
| New River Group:                                           |                                                    |                                          |                      |                          |
| Sewell (Davis)                                             | 2560                                               | 160                                      | 3.93                 | 0.72                     |
| Welch (Tap River)                                          | 2840                                               | 180                                      | 7.41                 | 0.62                     |
| Beckley (War Creek)                                        | 2800                                               | 150                                      | 4.76                 | 0.65                     |
| Fire Creek (Quinnont)                                      | 2540                                               | 130                                      | 6.60                 | 0.84                     |
| Pocahontas Group:                                          |                                                    |                                          |                      |                          |
| Pocahontas No. 6                                           | 2400                                               | 120                                      | 2.88                 | 0.70                     |
| Pocahontas No. 5                                           | 2700                                               | 100                                      | 6.23                 | 0.62                     |
| Pocahontas No. 4                                           | 2410                                               | 110                                      | 6.31                 | 0.64                     |
| Pocahontas No. 3                                           | 2440                                               | 140                                      | 4.70                 | 0.59                     |

It will be noted that the uppermost series given is the Monongahela series, there being no samples represent-

ing the overlying Dunkard series, which top out the highest beds in the Appalachian field; however, these coals are of very little commercial importance at the present time.

The results for each mine show the lowest softening temperature, the highest softening temperature and the average for the mine. The softening interval is tabulated in the same manner. In addition to these values the per cent ash and sulphur, on the dry coal basis, is given.

#### DISCUSSION OF RESULTS

The average values given for each bed provide a means of comparison of the different coals; however, of course, the average values are averages of the mines which are listed under each bed, consequently the



FIG. 2. TYPICAL FORMS OF CONES FUSED IN THE NO. 3 MELTER'S FURNACE

greater the number of mines sampled the more representative the values are of the bed. In some instances only a few mines are listed under the bed. In these cases the average values given are only representative of the mines sampled, and do not constitute a fair average of the bed. Beds such as the Pittsburgh, Sewell, Beckley and Pocahontas No. 3, from which a large number of samples have been tested and the softening temperature values for the various mines are uniform, the average values given may be taken as representative of the bed.

It will be noted that the softening interval values given in the table vary to a considerable extent. These values, as already explained, give the number of degrees interval between the temperature at which the tip of the cone fuses or bends and the temperature at which the cone has fused down to a spherical lump, which temperature is recorded as the softening temperature. The point at which the tip first fuses or bends is rather difficult to obtain exactly on account of the phenomena of warping and shrinking of the cones which sometimes result when the cones are subjected to heat. The softening interval is interesting mainly as a study of the viscosity of the melting ash. The softening temperature values given are the values which are used in comparing the different coals. This is the most definite and easiest point to check in the tests.

#### DISCUSSION OF COAL BEDS TESTED

Under the Monongahela series the Sewickley, Redstone and Pittsburgh beds are listed. Not sufficient mines are represented to give representative average values for the Sewickley and Redstone beds. The Pittsburgh bed, which is the most important coal bed in the

<sup>1</sup>Fieldner, A. C. and Feild, A. L., "A New Method and Furnace for the Determination of the Softening Temperature of Coal Ash Under Fuel-Bed Conditions," *Journal of Industrial and Engineering Chemistry*, Vol. 7, No. 10, 1915, pp. 829-857.  
<sup>2</sup>The Coal Catalog, Combined with Coal Field Directory, for the year 1918, Keystone Consolidated Publishing Co., Pittsburgh, Pa., pp. 579-588.



northern part of West Virginia and contains one of the most valuable fuels of the country, is fairly well represented. This bed varies considerably as to sulphur content in different regions. It will be noted, however, that the softening temperatures as given are fairly uniform, but are lower than many of the other beds listed.

The mines listed under the Conemaugh series are all coal banks from the Mahoning bed, which is of no commercial value but is mined for local use. The average softening temperature from these coal banks is practically the same as that of the Pittsburgh bed.

In the Allegheny series the lower Kittanning or No. 5 Block bed is a very important coal. This bed varies from a high volatile coal in the southwestern half of the state through an ordinary bituminous type of coal in Randolph and Barbour counties to a semi-bituminous coal in the North Potomac basin.\* As might be expected from a coal varying so much in composition, the values given for this bed vary over a wide range, but no doubt the mines listed give representative values for their immediate districts.

The coals listed under the Kanawha group of the Pottsville series are coals giving ash having a uniformly high fusing temperature. The No. 2 Gas is the most important and valuable bed of this group and is widely known commercially. This bed as well as others of this group contains coals giving ash having a high fusing temperature.

The New River group of the Pottsville series contains some of the best known coals of the country, coals having a low ash and sulphur content, also giving an ash with a high fusing temperature.

The Sewell bed, which is the most important of the New River group, is very well represented in the table. The mines tested give a very uniform fusibility of ash value, and the average value for the bed is good. This coal, which is semi-bituminous in character, is one of the famous steam-producing coals of the country and is the most extensively developed of the New River coals.

The Beckley bed, which is a very important member of the semi-bituminous coals of the New River group, shows some remarkably high fusibility values. The ash from this coal is of a specially refractory nature and this bed gives fusibility values higher than any other of the beds of West Virginia that were tested. This coal should prove of interest to consumers demanding a high grade coal giving an ash of an exceptionally high fusibility.

The last group listed and the oldest and lowermost of the West Virginia coals is the Pocahontas group, which contains the famous Pocahontas No. 3 bed of Mercer and McDowell counties. This seam produces the well known Pocahontas semi-bituminous coal, which is one of the purest coals of the country and is being used extensively as a steaming and coking coal. The average values given for this bed represent 246 samples, so should be very representative of this celebrated coal. As is seen, the figures representing the different mines are very uniform. Although the average softening temperature of this bed is not as high as some of the others, especially the Beckley bed, it is uniformly high and little trouble should be experienced from clinkering.

Grateful acknowledgment is made to A. C. Fieldner, chemist, formerly of the Pittsburgh Station of the Bureau of Mines, under whose supervision most of the tests were made. Many of the tests were made by Messrs. A. E. Hall, V. C. Allison, C. R. Locke, C. S. Purcell, W. C. Ratliff and O. C. Brown, all of the chemical laboratory of the Bureau of Mines.

Chemical Laboratory, U. S. Bureau of Mines,  
Pittsburgh, Pa.

## The War and the Nitrogen Industry\*

BY W. S. LANDIS

JUST sixteen years ago the writer had the good fortune to see in operation at Niagara Falls the first large scale unit for the fixation of atmospheric nitrogen. This costly experiment of Bradley and Lovejoy did not prove the commercial success anticipated, but in its two years of operation it served to attract the attention of the world to the nitrate phase of the industry. The principles so well demonstrated at Niagara, when carried to Europe with its more favorable natural advantages and economic conditions, started a development that has commercially survived to the present time. Had Bradley and Lovejoy enjoyed the advantages of Norway, we might today find their names as prominent in the industry as Pauling and Schönherr, if not Birke-land and Eyde.

### THREE TYPES OF NITROGEN FIXATION PROCESSES

The fixation of nitrogen has developed along three divergent lines with many secondary outgrowths. The oldest process dated back to Cavendish, who in 1785 undoubtedly produced some nitric acid by passing the electric spark through air. Bradley and Lovejoy in 1901 attempted to do the same thing on a commercial scale and had their apparatus in operation in 1902. Just about the time the Niagara work was abandoned Birke-land began his experiments in Norway, using a somewhat different style furnace. Schönherr followed with his furnace, and still later Pauling. The product of all of these processes was nitric acid or derivatives of the same. Many others have since entered the field, but have made little progress in a commercial way.

A second school, and I am including here only those processes which have survived in one form or another, is that which concerned itself with the fixation of atmospheric nitrogen in the form of cyanides and cyanamides. Frank and Caro for many years attempted to produce cyanide through the direct fixation of atmospheric nitrogen. Commercially unsuccessful in this attempt, they, however, succeeded in a small way in producing cyanamide from atmospheric nitrogen and calcium carbide about 1900, or just prior to the nitric acid work of Bradley and Lovejoy. They did not, however, make much progress in the development of their process in the early days, and it was not until 1906 that a commercial installation followed. Later followed the conversion of cyanamide to ammonia, and quite recently the oxidation of this ammonia to nitric acid.

The third school following the production of ammonia synthetically, from its elements, nitrogen and hydrogen, is represented in the work of Haber and

\* (a) West Virginia Geological Survey, Bull. II, "Levels and Coal Analyses," 1911, p. 296.

\* A paper read before the American Electrochemical Society on Oct. 1, 1915.

carried out almost simultaneously with Birkeland's developments in Norway.

These three systems of fixation which have survived to the present time are none of them twenty years old and in fact essentially had no producing capacity even twelve years ago. Ten years will actually cover the commercial history of the industry.

#### THE STATISTICS OF NITROGEN PRODUCTION

Before the advent of the fixation processes, the world's requirements of nitrogen were met by the nitrate beds of Chile, the recovery of ammonia in the coking of coal and the production of illuminating gas and from various vegetable meals and animal by-products. We are going to consider only the chemical nitrogen product in our further discussion. According to the best available statistics, ten years ago, or in 1908, the world's production of nitrogen in the form of Chilean nitrate and of sulphate of ammonia was equivalent to only 503,000 short tons of nitrogen. The fertilizer industry was the larger consumer of this nitrogen, and since the capacity of the cultivated acreage of the world for absorption of this nitrogen was fifty or one hundred times the above production, there was ample incentive for the development of an air fixation process.

In 1914, at the outbreak of the European war, the producing rate of the world in short tons of chemical nitrogen, according to the best available statistics, is given in the following table:

| Material:                                | Nitrogen,<br>Short Tons |
|------------------------------------------|-------------------------|
| Nitrate of soda.....                     | 425,000                 |
| Sulphate of ammonia.....                 | 285,000                 |
| Arc process products.....                | 11,000                  |
| Cyanamide products.....                  | 31,000                  |
| Synthetic ammonia and miscellaneous..... | 12,000                  |
| Total—short tons nitrogen.....           | 764,000                 |

In 1919, say five years later, the producing capacity of the world, including the United States Government nitrate plants now under construction, is estimated to be as follows:

| Material:                                | Nitrogen,<br>Short Tons |
|------------------------------------------|-------------------------|
| Nitrate of soda.....                     | 520,000                 |
| Sulphate of ammonia.....                 | 350,000                 |
| Arc process products.....                | 15,000                  |
| Cyanamide products.....                  | 360,000                 |
| Synthetic ammonia and miscellaneous..... | 116,000                 |
| Total—short tons nitrogen.....           | 1,341,000               |

#### UNIFORM INCREASE IN PRODUCTION

An analysis of the production statistics of the world for ten years prior to the outbreak of the war shows a very uniform rate of increase. The curve is almost exactly a straight line. If we carry this rate of increase forward into the future it indicates a producing rate for 1919 of 1,330,000 short tons of nitrogen, or essentially the same as our figure given above for actual production, 1,341,000 tons. Such a system of analysis, it seems, is justified in view of the very uniform rate of increase noted for years prior to the war, and we are forced to the single conclusion that as relates to the world as a whole there has not been the great over-expansion of producing capacity most of us have believed. The available nitrogen supply expanded under the influence of the war only to the point any one would have predicted in the spring of 1914 from a study of its past statistics.

In this connection it might be here added that about

1911 the world's production of nitrogen began to catch up with market demands as limited by the comparatively unexpanded trade channels which had not kept up with the increase of production. Prices slumped as a result, reaching the lowest point in the history of the industry in 1914, and only the outbreak of the war with its insistent demands saved a portion of the industry from financial disaster.

It is a question if a problem is confronting the world's nitrogen industry at the close of the war. Undoubtedly the demand will drop off somewhat with the advent of peace, but with the anticipated high food prices continuing for some time afterward, this drop in nitrogen consumption should not be excessive. On the other hand, many plants erected under the war-time emergency are so located geographically and economically that operation after the emergency is past will be impossible. We may, therefore, expect a material reduction in producing capacity. That the decrease in demand and in production will be somewhat of the same order is at least a plausible assumption, and we see no real reason for altering our earlier conclusion as to the existence of a real primary problem, as concerns supply and demand.

#### READJUSTMENT OF PRICES AND MARKETS IS BOUND TO COME

Of secondary interest, there is bound to be much readjustment of prices, markets, distribution, etc., for the new plants are located in many cases in consumption centers formerly drawing from a distance for their supplies. Former importers may become exporters and new products must supplant older varieties of materials. Legislation may even play an important part in affecting consumption not alone of the nitrogen, but even of the specific variety. The influence of these phases, secondary in a sense to supply and demand, cannot be foretold. A recurrence of the 1914 condition may ultimately occur again, particularly as there has been no expansion of propaganda and educational methods and sales organizations since 1914.

In the case of the United States the statistics, however, partake of a very difficult character. In 1914 the United States possessed no commercial fixation plants; the consumption was as follows:

#### U. S. CONSUMPTION OF NITROGEN IN 1914

| Material:                                      | Nitrogen,<br>Short Tons |
|------------------------------------------------|-------------------------|
| Nitrate of soda (import).....                  | 94,300                  |
| Equivalent sulphate of ammonia (domestic)..... | 36,600                  |
| Equivalent sulphate of ammonia (import).....   | 17,800                  |
| Cyanamide products (import).....               | 5,400                   |
| Total—short tons nitrogen.....                 | 154,100                 |

#### UNITED STATES NITROGEN STATISTICS

It is extremely difficult to estimate for 1919 a similar consumption rate. I am, however, reproducing here some figures which are at least representative of the magnitude to which the industry has grown, having included the best information on anticipated outputs of coke ovens and on the new Government nitrate plants now under construction and which will be in operation very early in the spring:

#### ESTIMATED PRODUCTION RATE 1919, U. S.

| Material:                           | Nitrogen,<br>Short Tons |
|-------------------------------------|-------------------------|
| Nitrate of soda.....                | 300,000                 |
| Equivalent sulphate of ammonia..... | 100,000                 |
| Cyanamide products (import).....    | 13,000                  |
| Cyanamide products (domestic).....  | 88,000                  |
| Synthetic ammonia.....              | 10,000                  |
| Total—short tons nitrogen.....      | 509,000                 |

The producing rate in the early part of 1919 will, therefore, be approximately three times that at the outbreak of the war. Before the war half the chemical nitrogen entered into the fertilizer industry, which for a considerable period of time has shown an increase of only about 10 per cent from year to year. Assuming this increase, applied to the whole industry, would have continued for the duration of the war, it is hardly to be expected that the consuming capacity at the beginning of 1919 should exceed 225,000 tons of nitrogen per year had there been no war.

#### INDUSTRY FACES UNUSUAL PROBLEM

Judging from past history, our only guidance, we can expect at the close of the war a more or less disturbed state of affairs lasting over an indefinite time. We have no reason for assuming an enormously increased market for nitrogen to develop with peace, and in fact the chances are greatly in favor of a decline below the estimated 225,000 tons. With a production capacity of over 500,000 tons and a maximum consumption of less than half that tonnage, the industry in the States faces an unusual problem.

Importation of nitrate of soda makes up over half the available tonnage. Undoubtedly a material reduction of this import will follow peace, possibly sufficient to balance supplies and demands. There will always be some demand for nitrate of soda in agriculture and the oxidation of ammonia will make only slow headway in the already equipped and amortized chemical plants, so we cannot hope for a complete cessation of nitrate imports. Certain fixation plants erected as war emergency plants will undoubtedly close down with the declaration of peace, or at least suspend during a period of removal to more favorable peace market localities. Exportation of surplus production is not excluded from contemplation.

#### NITROGEN INDUSTRY MUST UNDERGO CHANGE

The nitrogen industry of the States must undergo a complete change we must all admit. This enforced change, I believe, need not seriously affect the great producing interests of this country, but the distribution agencies are certain to be influenced. The changes of methods and materials will affect the consumer. Out of the whole can come much good.

For example, prior to the war, agriculture consumed about 50 per cent of the chemical nitrogen in the whole country in the form of mixed fertilizers. The ingredients, mostly low in content of plant food and collected from many places, were assembled at the seaboard and compounded there. This low plant food content, varying from 12 to 20 per cent of the whole, means high cost of assembling, mixing, bagging and transportation per unit of plant food. By the time the fertilizer had been transported 200 to 300 miles inland and distributed under an expensive system of credit the nitrogen cost the farmer about double its wholesale price at the ports. As a result 85 per cent of the fertilizer consumed in the country was used in a narrow strip of territory near the coast, and the enormous acreage of Middle Western cultivated lands went unfertilized. The high cost of the dilute fertilizer when transported to these states made its use either impossible or at least unattractive to the farmer from the standpoint of profitable return.

The great cereal crop-growing regions must have cheaper nitrogen to make available the vast market they present.

Now, neither the producer of the raw materials nor the compounder of the mixed fertilizer was a profiteer. A careful study of the situation—and statistics are available in ample quantity—shows that neither profited to more than a very moderate return on his invested capital. The difficulty lies in the enormous friction losses in handling a material averaging only between 12 and 20 per cent of valuable plant food and 80 to 88 per cent inert material. The labor, bags, freight and haulage applied to the inert material are lost. If they could be eliminated the cost of fertilizer could be reduced without either the producer of the raw materials or the compounder and distributor of the same suffering. With reduced cost to the farmer and more general distribution the cost of credits will be lowered. Half the price paid by the farmer went to the wholesaler of the raw materials and the other half for distribution. As this second half is largely proportional to the bulk handled, any means of reducing the inert material content should result in a lowering of these costs of mixing, bagging and distributing. The solution of the problem of a lowered cost of fertilizer is therefore logically one involving the production of a more concentrated material. And following the lowered cost will come the newer and larger markets with increased demand.

#### MUST FACE THE FACTS

The nitrogen industry of the United States, if it is to market its great production at the close of the war, must face these facts and be prepared to meet the issue. One of the youthful fixation processes has appreciated the situation and prepared itself through development of a concentrated fertilizer containing some 65 per cent plant food, more than four times as concentrated as an average mixed fertilizer. The cost of handling, mixing, bagging, freight and haulage will be cut in equal proportion to the concentration and it will be enabled to reach hitherto inaccessible markets, miles beyond the limit of the present dilute materials. The new fertilizer awaits only the close of the war and release of the ammonia supplies to enter the field. Crop tests have been carried out for some four to five years to show the value of nitrogen.

When fertilizer can be profitably put into the great Middle West the consumption will be enormous. Our apparently largely increased nitrogen production will not suffice to meet the demand. It would take the stimulating effect of several wars to build sufficient fixation plants to over-produce in such a market.

Thus the ten-year-old fixation industry with its freedom of action, absence of prejudice and broad appreciation of fundamental condition has not only come to the assistance of the Government in the war emergency, but has prepared itself to meet what might have been a serious national problem with the advent of peace. A closing of the plants with the world's shortage of food stocks is unthinkable, and yet such would appear on the face of statistics to have been the outcome had the problem not been attacked from its fundamentals. At least some of us do not look into the future with fear in spite of the figures.



## Book Reviews

A MANUAL OF CHEMICAL NOMOGRAPHY. By Horace G. Deeming, Ph.D. The University Press, Champaign, Illinois.

In this small pamphlet we have a most satisfactory practical treatment of the general method of graphical calculation, in its broadest sense, as applied to chemical problems of both scientific and industrial interest. That such methods in very many fields are of the greatest possible importance is not to be doubted; and the chemical profession owes a debt of gratitude to Dr. Deeming, not only for his general and excellent presentation of past work, but more especially for the new, original developments due entirely to him. This book, together with the accessories necessary for the practical application of the principles of the subject, which are now available, makes it possible for the first time for all chemists to employ this exceedingly useful method in their various calculations. And all chemists should consider it their duty to examine the book in order to see just what aid it can offer them in solving their problems, especially those which have more or less a routine nature.

CHEMICAL COMBINATION AMONG METALS, by Dr. Michele Giau and Dr. Clara Giau-Lollini. 341 pages. Price \$4.50 net. Philadelphia, P. Blackiston's Son & Co.

This book, which was awarded the prize of the Cagnola Foundation by the Royal Lombardy Institute of Science and Literature, has been rendered into very graceful English by Gilbert W. Robinson. It would be very noteworthy merely as a compilation presenting systematically the known binary equilibrium diagrams which give evidence of the occurrence of intermetallic compounds. Since the common conception of valency throws no light upon the formation of such entities, the authors make a main division of their subject into homopolar and heteropolar compounds, following Abegg. Thus, intermolecular forces are "polar" if they depend on the special affinity of the elements for electrons, while "unitary" forces lack this character. The valency of an element depends on the nature of the other elements with which it combines. Elements of distinct series in the Periodic System are heteropolar, while neighboring elements are homopolar. The greatest number of intermetallic compounds result from unitary forces and only in comparatively few cases are heteropolar compounds formed.

In another important chapter the authors outline what is known from systematic investigations of various physical properties of alloy series, such as conductivity, hardness, density and so on, pointing out that such studies are extremely important in reinforcing the evidence given by thermal analysis. Compounds are indicated by actual or submerged maxima on the liquidus; these compounds produce corresponding discontinuities or "singular points" on the curves representing a physical property plotted against composition.

The eminent Russian, Kurnakoff, has done much work in correlating thermak and electrical phenomena, and his work is referred to repeatedly by the authors. He has shown that some equilibrium diagrams exhibit thermal maxima which do not correspond to rational atomic proportions, while the curves for physical properties do not exhibit the expected discontinuities. Thus, there is much thermal evidence of a compound Bi<sub>2</sub>Tl, while fusion curves and electrical conductivity measurements have demonstrated the existence of a gamma phase between 55 and 65 atonic per cent bismuth—that is, in the same region as the hypothetical compound. This phase exists perfectly independently, but cannot be fitted into any of Roozeboom's types for solid solutions. Further, microscopic examination shows that it undoubtedly possesses the characteristics of a chemical compound. Such facts as these lend support to one of the most important conceptions of recent years—that there exist compounds of variable composition or "chemical individuals," defined by Wald as phases, which in a series

of equilibrium changes possess a notably constant composition.

While, as can be presumed, this book is largely a most useful compilation from a multitude of authorities, the authors present the results of some original, trail-blazing investigations showing that intermetallic compounds generally dissociate upon melting. They studied the lowering of the freezing point of such compounds by the addition of a metal which did not form solid solutions or new compounds, and their conclusions are based upon Van't Hoff's well-known formulas showing the relations between depression and the number of molecules and ions in the liquid.

It is regrettable that such an excellent text should possess such a repellantly-colored binding. The clear typography is poorly matched by the sketchy, undraftsmanlike diagrams, evidently reproduced exactly from the Italian edition, and strangely enough, without captions. Several errors in printing the formulas may be easily noted, but it is indeed a rare book in English which can boast "letter-perfect" in this respect.

## Personal

MR. ERL V. DAVELER is now mill superintendent of the Butte & Superior Mining Co., at Butte, Mont.

DR. HAROLD S. DAVIS has been appointed to the research staff of the H. Koppers Co., Pittsburgh, Pa., one of the largest manufacturers and operators of by-product coke ovens, benzol and toluol plants. Dr. Davis will carry on his work at the Mellon Institute.

MR. FRANCIS N. FLYNN is assistant general superintendent of the Balbach Smelting & Refining Co., Newark, N. J.

MR. JOHN E. GALVAIN has been elected president of the Ohio Steel Foundry Company, Lima, Ohio. He has been operating vice-president since its organization in 1907 and has taken an active part in the organization, having designed and erected the Lima plant.

MR. C. C. GORDON, who is operating a custom smelter near Yauli, in Central Peru, is in the United States investigating chloridizing volatilization processes.

MR. C. J. HALL is now with the Copper Queen Reduction Works, Douglas, Ariz., having resigned his position with the Garfield Smelting Co., Garfield, Utah.

MR. E. C. HICKMAN is now assistant superintendent with the St. Joseph Lead Co., at Hercules, Mo. He was formerly with the American Smelting & Refining Co., Murray, Utah.

MR. EDWARD K. JUDD has resigned as managing editor of the Bulletin of the American Institute of Mining Engineers to take a position in the operating department of the American Metal Co., 61 Broadway, New York.

MR. WILLIAM M. KINNEY has been appointed general manager of the Portland Cement Association to succeed Mr. H. E. Hilt, resigned.

MR. OTTO KRESS, who has been connected with the U. S. Forest Products Laboratory, Madison, Wis., in charge of its research work on pulp and paper, is now with E. I. du Pont de Nemours & Co., Wilmington, Del., as director of the new technical dyestuff laboratory in the dyestuff sales department.

MR. JAMES M. McCLEAVE is now president of the Western Research Corporation, 514 Eighteenth Street, Denver, Colo.

MR. BYRON T. MOTTINGER announces that after Jan. 1, 1919, he will be associated as chief engineer and master mechanic with the Quaker City Rubber Co., Wissinoming, Philadelphia, Pa.

MR. A. IRA RENICK has resigned as mill superintendent for the Climax Molybdenum Company, and is now at Anaconda, Mont. Mr. Renick has been succeeded at Climax, Mont., by Mr. O. G. ANDERSON.

MR. FOREST RUTHERFORD, consulting metallurgical engineer, has returned to New York from Colorado.

MR. L. E. SCHUMACHER, who for the past eight years

has been chief inspector of the Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa., has been promoted to works manager of the Krantz Manufacturing Co. of Brooklyn, N. Y., the latest subsidiary of the former company.

MR. E. GYBON SPILSBURY has been appointed to represent the American Institute of Mining Engineers at the Engineering Congress in Paris. The delegation from the United States, invited by the French Government, is composed of members of the four national engineering societies. These representatives sailed on Dec. 5 and expect to be away about six weeks.

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## Obituary

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MR. H. P. CORLISS, the discoverer of alpha-naphthalamine as a flotation agent, died of pneumonia at Ray, Ariz., on Nov. 16.

MR. EDWARD RANDOLPH, president of the Balbach Smelting and Refining Co., Newark, N. J., died suddenly in his office Oct. 11, 1918.

## Current Market Reports

### The Iron and Steel Market

Our last review noted that the thought was then rising that the War Industries Board would not indulge in further price fixing, the thought immediately after the signing of the armistice having been that price fixing would continue, even, perhaps, to the extent of fixing minimum prices so as to prevent a slump in the market. This "rising thought" has since become universal. The War Industries Board indicated that it would not fix prices on any material after the present quarter unless urged to do so, with presentation of cogent reasons, and the industry has come to the conclusion that it does not want prices to be fixed.

Market conditions and prospects can therefore be discussed on the basis that there will be no further price fixing by the War Industries Board. The common thought seems to have been, at least until very lately indeed, that such abandonment of price fixing would leave the iron and steel market altogether adrift, and the word "chaos" has even been used. Nothing of the sort. The iron and steel market is left in a very familiar condition indeed, the condition that obtained in the summer of 1900, the second quarter of 1903, the latter part of 1907, the latter part of 1910 and the summer of 1913. In all those cases there had previously been an active demand, the establishment of a relatively high level of prices with an absolutely steady market and full order books, while there was no further buying except for the filling of immediate and pressing wants. To-day the alignment is precisely the same, though of course each time such a situation arises the proportions of the items that make up the situation are somewhat different.

### PHILOSOPHY OF THE STEEL MARKET

The American iron and steel market may have a philosophy of its own. The writer does not know, not being conversant with other philosophies, but the philosophy of the steel market is perfectly clear, and can either be read from plainly recorded history or can be developed from recognized principles, according to whether one prefers the inductive or comparative method of reaching conclusions.

As to the principles involved: First, the iron and steel producers have a large tonnage of business on their books. Some was entered during the period of price control, and therefore at Government prices. Some was entered before the period of price control, at various prices. Speaking in averages, prices before March 1, 1917, were below the Government levels later established, while prices afterward, to the time of Government control, were at higher than Government levels. There is very little tonnage at less than Government prices. Second, there is buying now, by those who want material at once and who do not balk at price because they can turn the material over at once. Third, there is no forward or "investment" buying and no inquiry along that line. Such buyers have no price in mind at which they would take hold if they were quoted the price. Obviously the attractive course for the individual seller would be to maintain existing prices, which are well known and understood. Those who would buy at all would buy more readily at these prices than in an uncertain and declining market. Those who have material due them on contract would much more readily accept it at the contract price than if the market were declining. Nothing is lost and much is gained.

The records are clear that this is precisely what iron and steel producers have done in the past in similar circumstances. In all the five cases cited there was the individual incentive to hold to prices. There was always more or less "team work," in the earlier times helped somewhat by pools and associations and after the collapse of demand in 1907 by the "Gary dinner" system. Those were merely helps, however, the individual incentive being naturally present.

### WHEN WILL PRICES DECLINE?

The immediate question, therefore, is not how far prices will decline but how long it will be before they begin to decline. With prices so high it is not the presence of active demand, but its absence, that operates to maintain the existing price level. There is no incentive to cut, while there is an incentive not to cut, but to nurse the existing contract tonnage on books and effect the largest possible deliveries against it. Some contracts are firmer, legally, than others, but the amounts of money are so large that many buyers would be ruined by taking material at contract prices if a slump in the market made it that their competitors could buy at much less. Of course there may be quiet shading by some producers, but unless pronounced it can be ignored. There was more or less shading throughout 1908, very quiet, and the Gary price maintenance was not formally abandoned until Feb. 20, 1909. When the dwindling of the volume of contract business remaining and the development of a buying disposition needing to be encouraged progress far enough that the balance is tipped and the incentive to cut becomes greater than the incentive not to cut, the market breaks. That break may occur a few weeks after Jan. 1, 1919, or a few months after that date. It will be the most remarkable accident that ever befell the market if it occurs in January. Of course there is a bare possibility of a new and lower level of prices being put out, perhaps under Steel Corporation leadership, in hope of the market being stabilized upon it, but that is extremely improbable.

As indicated in last report, buyers may be divided into classes, according to the period of time in which they are able to reconvert their purchases into cash. It may be estimated roughly that in the steel market as constituted before the war fully one-half the buying was of material for construction purposes intended to return the capital in a period of ten years or more. There can be no such buying at present and the banked up demand of those who can turn over their purchase quickly cannot long keep the industry operating at capacity.

#### BUYER REQUIRES STABLE MARKETS

Obviously the investment buyer is not simply waiting for lower iron and steel prices. If that were all, the producers could easily reach an understanding with him. He wants to know something about what is going to occur in the world, and in particular he requires a stable market for labor and the other materials he must buy, for when steel is bought in the investment sense it requires labor and materials to put it into employment. Sometimes, as in the case of an office building, the steel itself is but a small part of the total cost. In many cases the investment buyer would refuse steel as a gift, if he were required to utilize it at once by buying the other materials and employing the labor necessary to do so.

The delay in the development of investment buying was of course entirely to be expected. In its policy of allowing the mills to continue at work for a time on war steel orders, when the material will hardly be needed, the Government did not contemplate continuing this expenditure until the investment buyer should appear. The policy is an altogether temporary one, to relieve the shock, and the cancellations of orders in process of being filled have been heavier than has been generally reported.

Apart from this necessary delay before regular investment buying is ready to take hold there are two unfortunate circumstances as to steel demand. The first is that the Emergency Fleet Corporation has a large excess of hulls waiting for equipment, launchings having exceeded vessel completions by more than a million tons deadweight, and there is also an accumulated surplus of more than a million tons of plates, represented by the mill shipments minus the plates necessarily in transit or process of fabrication or already entered into hulls. These excesses were an expensive but justifiable factor of safety at one time, but now the program involves greatly reduced plate shipments for account of the Fleet Corporation until a balance is produced. The second unfortunate circumstance is that the railroad problem is in such shape that there is no buyer who can take hold in anything like a free way.

#### RAILROADS IN A QUANDARY

Congress must decide what is to be done with the railroads. The Railroad Administration cannot buy freely, for the roads may be returned to their former owners, who would object to almost any prices paid for steel, as indeed they have objected to prices paid during the war, asking the Government to stand the difference between the price and the post-war value. The individual railroads cannot buy, as they have not the incentive to build up the properties and do not know whether they can afford to buy. The railroads have hitherto

been the steel industry's best single customer, but no buying of real magnitude can occur until something like a decision has been reached as to who is eventually to own and operate the railroads.

Beyond question there will eventually be a heavy demand for iron and steel, chiefly in the great American market rather than for export, and the demand may continue for several years, but there is uncertainty when it will develop. As in geology, the time element is the most uncertain. So it can be predicted that there will be maintenance of the existing prices and declining mill activity, then a break in prices, buying by investors, a rising market again and a sustained period of demand.

#### The Non-Ferrous Metal Market

*Saturday, Dec. 7.*—In general fair stocks of the non-ferrous metals are being held by the consumers, who are not inclined to buy more and feel that by not forcing the market they will be able to replace their stocks more economically later.

*Aluminum.*—The Government prices on ingots 98 to 99 per cent Al are \$660 a ton f.o.b. plant in 50-ton lots; \$662 down to 15-ton lots; and \$666 down to 1-ton lots, which prices will continue the remainder of the year. Prices per pound for small lots vary from 40c. to 45c.; sheet aluminium, 18 ga. and heavier, 42c.; powdered aluminium, 100 mesh, 70c.

*Antimony.*—The volume of sales is not large even at prices from 8½c. to 8¾c. per pound.

*Copper.*—The price of \$520 per ton for carload lots and 27½c. per pound for small quantities was continued for another period at the conference held on Oct. 25 at Washington. Production declined 3400 tons during November due to the hesitating market conditions. Casting copper is being quoted at 23c. per pound.

|                                 |     |        |          |
|---------------------------------|-----|--------|----------|
| Copper sheets, hot rolled.....  | lb. | \$0.36 | —\$0.37½ |
| Copper sheets, cold rolled..... | lb. | .37    | — .38½   |
| Copper bottoms.....             | lb. | .44    | — .45½   |
| Copper rods.....                | lb. | .36    | — .37    |
| Copper wire.....                | lb. | .29½   | — .30    |
| High brass wire.....            | lb. | .28½   | — .29½   |
| High brass sheets.....          | lb. | .28    | — .29    |
| High brass rods.....            | lb. | .28½   | — .29½   |
| Low brass wire.....             | lb. | .32½   | — .34    |
| Low brass sheets.....           | lb. | .32½   | — .34    |
| Brazed brass rods.....          | lb. | .33½   | — .35    |
| Brazed brass tubing.....        | lb. | .33    | — .34    |
| Brazed bronze tubing.....       | lb. | .42½   | — .44½   |
| Seamless copper tubing.....     | lb. | .41    | — .42    |
| Seamless bronze tubing.....     | lb. | .45    | — .46    |
| Seamless brass tubing.....      | lb. | .37½   | — .39½   |
| Bronze (bronze) powder.....     | lb. | 1.00   | — 1.15   |

*Lead.*—Lead has been the first of the major military metals to decline. Transactions are not large and prices at East St. Louis are \$135 per ton and 7.05c. per pound in New York.

*Silver.*—Due to the flow of silver to Asia in payment for munitions and the greatly increasing industrial consumption in photography, motion picture reels and silverware, there is a shortage of silver even at the present government price of \$1.01½ per ounce.

*Tin.*—The Tin Committee of the American Iron and Steel Institute has not yet announced the official price on tin. No doubt an understanding will have to be had with the producers before a final statement can be made public and as they are all in distant foreign countries, considerable time will elapse in intercommunication, with the added possibilities that prices will not be legally fixed but adjusted by economic conditions as to demand by that time. The market is dull at a price of 72½c. per pound.

*Tungsten.*—The buyers of tungsten are decidedly cautious, though there is not likely to be any unlooked-for changes. Prices are nominal, scheelite bringing \$25, wolframite, \$20 to \$21, with no sales of low grade reported.

*Zinc.*—The spelter market continues to be on a firm basis, being little affected by the present transition period. Prime spot, New York, is \$172; East St. Louis, \$165 per ton; East St. Louis, December delivery, \$164; January, \$160; February, \$158, and March, \$157 per ton. Zinc dust, 13½c. to 16c. Sheet zinc, 15c. lb.



## OTHER METALS

|                 |        |               |
|-----------------|--------|---------------|
| Lithium .....   | lb.    | \$3.50—\$3.65 |
| Cadmium .....   | lb.    | 1.50 .....    |
| Cobalt .....    | lb.    | 2.50—3.50     |
| Magnesium ..... | lb.    | 1.75—2.10     |
| Mercury .....   | 75 lb. | 120.00 .....  |
| Mercury .....   | lb.    | 1.95 .....    |
| Nickel .....    | lb.    | 1.40—1.43     |
| Tungsten .....  | lb.    | 34.00 .....   |
| Iridium .....   | oz.    | 175.00 .....  |
| Palladium ..... | oz.    | 135.00 .....  |
| Platinum .....  | oz.    | 108.00 .....  |

## The Chemical Market

**HEAVY CHEMICALS:**—At the present time most chemicals, with only a few exceptions, show very little movement of character. Buyers in the general trade are not disposed to purchase ahead any quantities of material, but are seemingly confining their attentions to immediate needs, which therefore tends to keep business quiet and of a routine nature. While caustic soda has had a flurry of activity, this condition existed only temporarily, with the final disposition on the part of buyers to await developments of shipping space. It is evident that the necessity of cargo space is having a tendency to curtail the volume of trading and whatever stock may be accumulated will be taken up by export demand when this situation becomes easier. Soda ash during the interval has been considerably neglected while the position of bleaching powder has developed more firmly on the recent advance.

**Bleaching Powder:**—The item has had a varied experience; while prices were on the decline for a period, a firming up set in, particularly for material in export drums, which are none too liberal in supply, while trading for domestic drums is somewhat easier. The product in export drums is quoted at 3½c. to 3¾c. works, while that in domestic drums is offered at 2½c. to 2¾c.

**Soda Ash:**—There has been no particular buying interest evident in any of the items that come under this heading and cheap offerings have frequently appeared on the market. Bag material was offered as low as \$2.25 per hundred pounds ex dock, while material from the warehouse was available at \$2.30 to \$2.35, though this price could possibly be shaded on a firm bid. Barrels were subject to no important movement and were held at a variation of prices ranging from \$2.65 to \$2.80 per hundred pounds, though in Chicago offerings were made as low as \$2.55. Double bags from western shipping points were quoted at from \$2.70 to \$2.90, but no particular buying interest was in evidence.

**Caustic Soda:**—The recent announcement of the war trade board, that all restrictions relative to this item have been lifted and that licenses would be granted for any destination, has had a very noticeable effect and prices were advanced from \$3.95 to \$4.20. However, a slackening up set in when the question of cargo space arose and a firm but quiet market has since prevailed. Material from the warehouse was quoted at \$4.20 with \$4.30 being the asking price for F. A. S. delivery. The ground caustic is subject to no important call and is offered at 5c. per pound.

**Potash:**—The lack of buying interest has brought about declines in prices, throughout, and weak holders are seemingly playing havoc with the market, considering the cheap offerings made. The U.S.P. product declined from \$1.75 and \$1.85 per pound to \$1.60 and \$1.70 with virtually no inquiry for the technical product that is quoted at \$1.40 to \$1.50.

**Sodium Acetate:**—Comparatively little interest has been taken lately in this product and the only activity in the market is created by the frequent offerings made. Quotation for carload lots are made at 21c. to 22c. while lesser quantities are offered at 23c. to 25c.

**Zinc Oxide:**—The only interest at the moment is for export purposes while in the local market quietness prevails. Standard brands are being quoted at from 13½c. to 14c.

**Bicarbonate of Soda:**—The firm situation that has been in evidence for this item still prevails, and prices are continued at their former levels. Barrels from the works are offered at 3½c. per pound, while material on the spot is quoted at 3½c. to 3¾c. with the price of keg material being a fraction of a penny higher.

**Nitrate of Soda:**—Restrictions relative to this material have been rescinded and orders are now being accepted for the product, but the entire situation at the moment is by no means easy; however, it is the impression that in January matters will be definitely changed. November prices are \$4.40 ex dock and \$4.52½ ex dock for the 95% and the 96% respectively. The statistical position is as follows:

|                      | PRODUCTION (IN TONS) |           |           |
|----------------------|----------------------|-----------|-----------|
|                      | 1918                 | 1917      | 1916      |
| In October .....     | 239,600              | 253,400   | 235,000   |
| For ten months ..... | 2,317,500            | 2,419,700 | 2,331,100 |

|                              | Shipments from the West Coast for October<br>(as cable) |         |         |
|------------------------------|---------------------------------------------------------|---------|---------|
|                              | 1918                                                    | 1917    | 1916    |
| To Europe, tons .....        | 60,000                                                  | 96,100  | 146,100 |
| To United States, tons ..... | 254,750                                                 | 147,700 | 88,700  |
| To other parts, tons .....   | 11,600                                                  | 41,700  | 51,000  |

|                              | Shipments from Jan. 1 to Oct. 1 |           |           |
|------------------------------|---------------------------------|-----------|-----------|
|                              | 1918                            | 1917      | 1916      |
| To Europe, tons .....        | 806,600                         | 893,700   | 1,205,150 |
| To United States, tons ..... | 1,573,050                       | 1,218,400 | 987,800   |
| To other parts, tons .....   | 95,200                          | 152,600   | 211,950   |

**COAL TAR PRODUCTS:**—With a few exceptions there were no new developments in this market and despite the quietness that has prevailed prices were generally firmly maintained, except in the crude products, of which some have been subject to a decline, particularly toluol, which went down with a swoop, and cheap offerings appeared in the resale market. Many of the intermediates are still in scant supply, which tends to maintain prices, but the consuming trade is not so pressing as to even affect this situation. It appears to be the general attitude on the part of buyers to await developments, and they are inclined to believe the recent occurrences will bring about a reduction in prices. Benzol and phenol have not changed in prices and the governing conditions in this market remain as previously indicated.

**H. Acid:**—The item is one that is now more free in supply, but this condition has apparently been brought about by the lack of buying interest. However, no price concessions are made to encourage business and the situation remains firm.

**Phenol:**—The market has undergone no reportable change; large producers maintain their former prices; however, some weak holders are offering in the resale market 2c. and 3c. below manufacturers' quotations.

**Benzol:**—Quietness prevails in this market and the only movement at the moment is of a routine nature with no desire on the part of purchasers to buy up a surplus stock. Quotations for the commodity in tank cars are subject to no change, which also applies to drum material.

**Paraphenylenediamine:**—The usual trading that is in evidence for this product is reported to be passing, but otherwise no particular interest is noted. There are various grades of the material, therefore a wide range of prices is heard.

**Diphenylamine:**—Spot material is now more liberal and a rather steady volume of business is evident. Otherwise no material change is noted, with prices being firmly maintained.

**Alpha Naphthol:**—Users of this product appear to have eased up buying and stocks are supposed to have accumulated, but producers firmly maintain their prices for both the crude and refined products.

**Aniline Oil:**—While no surface stocks are reported in any one direction, the lack of buying interest has seemingly had some effect on the market and in some instances prices have declined 1c. to 2c.

**Aniline Salts:**—Stocks of this product are more liberal for immediate shipment, but the item appears to be neglected, although dealers up to the present writing have not altered their previous quotations.

**Benzidine:**—Locally there is no important interest displayed in the item, although a fair volume of business is passing for the base product, for export purposes, while the sulphate is lagging. Neither the base or sulphate are subject to any price changes, previous quotations being continued.

## General Chemicals

## WHOLESALE PRICES IN NEW YORK MARKET DEC. 6, 1918

|                                                   |         |        |               |        |
|---------------------------------------------------|---------|--------|---------------|--------|
| Acetic anhydride                                  | lb.     | 1 60   | —             | 1 85   |
| Acetone                                           | lb.     | 2 50   | —             | 2 25   |
| Acid, acetic, 28 per cent                         | wt.     | 5 96   | —             | 6 11   |
| Acetic, 36 per cent                               | wt.     | 10 76  | —             | 10 87  |
| Acetic, glacial, 99 per cent, anhydrous           | wt.     | 19 00  | —             | 19 20  |
| Boric, crystals                                   | lb.     | 1 31   | —             | 1 25   |
| Citric, crystals                                  | lb.     | 1 18   | —             | 1 25   |
| Hydrochloric, C. P.                               | lb.     | —      | Nominal       | —      |
| Hydrochloric, 30 per cent, in barrels             | lb.     | —      | 08            | 08 1/2 |
| Lactic, 44 per cent                               | lb.     | 15     | —             | 16     |
| Lactic, 22 per cent                               | lb.     | 06     | —             | 07     |
| Molybdic, C. P.                                   | lb.     | 6 90   | —             | 7 40   |
| Nitric, 36 deg.                                   | lb.     | —      | Nominal       | —      |
| Nitric, 42 deg.                                   | lb.     | 08 1/2 | —             | 10     |
| Oxalic, crystals                                  | lb.     | 40     | —             | 43     |
| Phosphoric, 47-50 per cent paste                  | lb.     | 07 1/2 | —             | 10     |
| Phosphoric, ref. 50 per cent                      | lb.     | 35     | —             | 40     |
| Picric                                            | lb.     | 75     | —             | 85     |
| Pyrogallic, resublimed                            | lb.     | 3 25   | —             | 3 50   |
| Sulphuric, 60 deg.                                | ton     | 25 00  | —             | 26     |
| Sulphuric, oleum (Fumme), tank cars               | ton     | 60 00  | —             | 65 00  |
| Tannic, U. S. P., bulk                            | lb.     | 1 40   | —             | 1 50   |
| Tartaric, crystals                                | lb.     | 86     | —             | 95     |
| Tungstic, per lb. of W                            | lb.     | 1 70   | —             | 1 75   |
| Alcohol, sugar cane, 188 proof                    | gal.    | 4 91   | —             | 92     |
| Alcohol, wood, 95 per cent                        | gal.    | 91 1/2 | —             | 92     |
| Alcohol, denatured, 180 proof                     | gal.    | 69     | —             | 69     |
| Alum, ammonium lump                               | lb.     | 07 1/2 | —             | 08 1/2 |
| Alum, chrome ammonium                             | lb.     | 18     | —             | 19     |
| Alum, chrome potassium                            | lb.     | 20     | —             | 22     |
| Alum, chrome sodium                               | lb.     | 12 1/2 | —             | 13     |
| Alum, potash lump                                 | lb.     | 09 1/2 | —             | 10     |
| Aluminum sulphate, technical                      | lb.     | 02     | —             | 02 1/2 |
| Aluminum sulphate, iron free                      | lb.     | 03 1/2 | —             | 04     |
| Ammonia, anhydrous, 26 deg., carbonyls            | lb.     | 08 1/2 | —             | 09     |
| Ammonia, anhydrous                                | lb.     | —      | Nominal       | —      |
| Ammonium carbonate                                | lb.     | 12     | —             | 13     |
| Ammonium nitrate                                  | lb.     | —      | (Fixed Price) | 15     |
| Ammonium sulphate domestic                        | lb.     | 07 1/2 | —             | 08     |
| Amyl acetate                                      | gal.    | 5 30   | —             | 5 35   |
| Arsenic, white                                    | lb.     | 09 1/2 | —             | 10     |
| Arsenic, red                                      | lb.     | 65     | —             | 73     |
| Barium carbonate, 99 per cent                     | ton     | 80 00  | —             | 90 00  |
| Barium carbonate, 97-98 per cent                  | ton     | 65 00  | —             | 67 00  |
| Barium chloride                                   | ton     | 70 00  | —             | 80 00  |
| Barium sulphate (Blanc Fixe, Dry)                 | ton     | 04 1/2 | —             | 05     |
| Barium nitrate                                    | lb.     | 12     | —             | 13     |
| Barium peroxide                                   | lb.     | 30     | —             | 32     |
| Bleaching powder, 35 per cent chlorine            | lb.     | 03     | —             | 03 1/2 |
| Borax, crystals, sacks                            | ton     | 08 1/2 | —             | 09     |
| Bromine, crude                                    | ton     | 65 00  | —             | 70 00  |
| Bromine, technical                                | lb.     | 75     | —             | 85     |
| Calcium acetate, crude                            | lb.     | 04     | —             | 05     |
| Calcium carbide                                   | lb.     | 15     | —             | 17     |
| Calcium chloride, 70-75 per cent, fused, lump     | ton     | 22 00  | —             | 24 00  |
| Calcium peroxide                                  | lb.     | 1 50   | —             | 1 70   |
| Calcium phosphate                                 | lb.     | 22     | —             | 23     |
| Calcium sulphate, 98-99 per cent                  | lb.     | 09     | —             | 09 1/2 |
| Carbon bisulphide                                 | lb.     | 08     | —             | 09     |
| Carbon tetrachloride, drums                       | lb.     | 20     | —             | 25     |
| Carbonyl chloride (phosgene)                      | lb.     | 1 10   | —             | 1 50   |
| Caulic potash, 88-92 per cent                     | lb.     | 67     | —             | 72     |
| Caulic soda, 76 per cent                          | 100 lb. | 4 15   | —             | 4 25   |
| Chlorine, liquid                                  | lb.     | 13     | —             | 15     |
| Coal oil                                          | lb.     | 1 60   | —             | 1 65   |
| Cobalt oxide                                      | lb.     | 02 1/2 | —             | 02 1/2 |
| Copper                                            | lb.     | 30     | —             | 31     |
| Copper carbonate                                  | lb.     | 75     | —             | 78     |
| Copper cyanide                                    | lb.     | 09 1/2 | —             | 09 1/2 |
| Copper sulphate, 99 per cent, large crystals      | lb.     | 68     | —             | 73     |
| Cream of tartar, crystals                         | 100 lb. | 3 10   | —             | 3 40   |
| Epsom salt, bags, 1 1/2 P                         | 100 lb. | 1 60   | —             | 1 65   |
| Formaldehyd, 40 per cent                          | lb.     | 02 1/2 | —             | 03     |
| Glauber's salt                                    | lb.     | 63     | —             | 65     |
| Glycerine, bulk, C. P.                            | lb.     | 4 25   | —             | 4 30   |
| Iodine, resublimed                                | lb.     | 17     | —             | 17 1/2 |
| Iron oxide                                        | lb.     | 15     | —             | 18     |
| Lead acetate, white crystals                      | lb.     | 12     | —             | 14     |
| Lead arsenate (Paste)                             | lb.     | 15     | —             | 18     |
| Lead nitrate                                      | lb.     | —      | Nominal       | —      |
| Litharge, American                                | lb.     | 1 50   | —             | 2 05   |
| Lithium carbonate                                 | lb.     | 16     | —             | 17     |
| Magnesium carbonate, technical                    | lb.     | 14     | —             | 15     |
| Nickel salt, single                               | lb.     | 12     | —             | 13     |
| Nickel salt, double                               | lb.     | 10     | —             | 10     |
| Phosgene, sec. carbonyl chloride                  | lb.     | 1 17   | —             | 1 20   |
| Phosphorus, red                                   | lb.     | 1 20   | —             | 1 25   |
| Phosphorus, yellow                                | lb.     | 40     | —             | 45     |
| Potassium bicarbonate                             | lb.     | 1 25   | —             | 1 26   |
| Potassium bromide, granular                       | lb.     | 38     | —             | 40     |
| Potassium carbonate calcined, 85-90 per cent      | lb.     | 38     | —             | 40     |
| Potassium chlorate, crystals                      | lb.     | 60     | —             | 70     |
| Potassium cyanide, 98-99 per cent                 | lb.     | 3 75   | —             | 3 80   |
| Potassium iodide                                  | ton     | 300 00 | —             | 350 00 |
| Potassium nitrate, 80-85 p. c. basis of 80 p. c.  | ton     | 1 50   | —             | 1 75   |
| Potassium permanganate, U. S. P.                  | lb.     | 2 30   | —             | 2 50   |
| Potassium prussiate, yellow                       | lb.     | 88     | —             | 95     |
| Potassium sulphate, 90-95 p. c. basis of 90 p. c. | ton     | 47     | —             | 48     |
| Rochelle salts                                    | lb.     | 23 1/2 | —             | 24     |
| Salammoniac, grav. gran.                          | 100 lb. | 22     | —             | 1 65   |
| Salammoniac, white gran.                          | 100 lb. | 1 40   | —             | 1 65   |
| Salt soda                                         | 100 lb. | 1 00   | —             | 20 00  |
| Salt cake                                         | 100 lb. | 1 00   | —             | 20 00  |
| Silver cyanide, based on market price of silver   | lb.     | 6 1/2  | —             | 6 1/2  |
| Silver nitrate                                    | 100 lb. | 2 40   | —             | 2 40   |
| Soda ash, 58 per cent light, flat                 | 100 lb. | 3 40   | —             | 3 60   |
| Soda ash, 58 per cent, dense, flat                | 100 lb. | 3 40   | —             | 3 60   |
| Sodium acetate                                    | lb.     | —      | Nominal       | —      |
| Sodium bicarbonate, domestic                      | lb.     | 03 1/2 | —             | 04     |
| Sodium bicarbonate, English                       | lb.     | 18 1/2 | —             | 20     |
| Sodium bicarbonate, technical                     | lb.     | 12     | —             | 14     |
| Sodium bisulphite, p. w. d.                       | lb.     | 25     | —             | 25 1/2 |
| Sodium chlorate                                   | lb.     | 30     | —             | 30     |
| Sodium cyanide                                    | lb.     | 17     | —             | 18     |
| Sodium fluoborate, commercial                     | lb.     | 17     | —             | 18     |

|                                        |         |        |         |        |
|----------------------------------------|---------|--------|---------|--------|
| Sodium hyposulphate                    | lb.     | 3 10   | —       | 3 50   |
| Sodium molybdate, per lb. of Mo        | lb.     | 2 50   | —       | —      |
| Sodium nitrate, 95 per cent            | 100 lb. | 4 1/2  | —       | 5 06   |
| Sodium nitrite                         | lb.     | 27     | —       | 30     |
| Sodium peroxide                        | lb.     | 35     | —       | 45     |
| Sodium phosphate                       | lb.     | 34     | —       | 34 1/2 |
| Sodium prussiate, yellow               | lb.     | 03     | —       | 06     |
| Sodium silicate, liquid (60 deg.)      | lb.     | 04     | —       | 04     |
| Sodium sulphide, 30 per cent, crystals | lb.     | 04 1/2 | —       | 05 1/2 |
| Sodium sulphate, 98 per cent, fused    | 100 lb. | 08     | —       | 09     |
| Sodium sulphate                        | lb.     | 05 1/2 | —       | 06     |
| Strontian nitrate                      | lb.     | 25     | —       | 30     |
| Sulphur, chloride, drums               | lb.     | 07 1/2 | —       | 09     |
| Sulphur dioxide, liquid, in cylinders  | lb.     | 15     | —       | 40     |
| Sulphur, flowers, sublimed             | 100 lb. | 3 70   | —       | 4 30   |
| Sulphur, r. c. l.                      | 100 lb. | 3 70   | —       | 3 85   |
| Sulphur, crude                         | ton     | 65 00  | —       | 70 00  |
| Tin bichloride, 50 deg.                | lb.     | 28     | —       | 29     |
| Tin oxide                              | lb.     | —      | Nominal | —      |
| Zinc carbonate                         | lb.     | 18     | —       | 20     |
| Zinc chloride                          | lb.     | 15     | —       | 15 1/2 |
| Zinc cyanide                           | lb.     | —      | Nominal | —      |
| Zinc dust, 550 mesh                    | lb.     | 13 1/2 | —       | 14     |
| Zinc oxide, American process XX        | lb.     | 12     | —       | 14     |
| Zinc sulphate                          | lb.     | 04 1/2 | —       | 06 1/2 |

## Coal Tar Products (Crude)

|                                       |      |      |               |       |
|---------------------------------------|------|------|---------------|-------|
| Benzol, pure, water white             | gal. | 22   | —             | 27    |
| Benzol, 90 per cent                   | gal. | 25   | —             | —     |
| Toluol, in tanks                      | gal. | —    | (Fixed Price) | 1 50  |
| Toluol, for non-aqueous use, in drums | gal. | —    | (Fixed Price) | 1 50  |
| Xylol, pure, water white              | gal. | 45   | —             | 55    |
| Solvent naphtha, water white          | gal. | 18   | —             | 25    |
| Solvent naphtha, crude, heavy         | gal. | 12   | —             | 15    |
| Cresol, 25 per cent                   | gal. | 45   | —             | 55    |
| Dip. oil, 20 per cent                 | gal. | 40   | —             | 45    |
| Pitch, various grades                 | ton  | 8 00 | —             | 20 00 |
| Carbolic acid, crude, 95-97 per cent  | lb.  | 07   | —             | 10    |
| Carbolic acid, crude, 50 per cent     | lb.  | 60   | —             | 65    |
| Carbolic acid, crude, 25 per cent     | lb.  | 35   | —             | 38    |
| Cresol, U. S. P.                      | lb.  | 19   | —             | 20    |

## Intermediates, Etc.

|                                |     |       |         |        |
|--------------------------------|-----|-------|---------|--------|
| Alpha naphthol, crude          | lb. | 1 00  | —       | 1 10   |
| Alpha naphthol, refined        | lb. | 1 50  | —       | 1 60   |
| Alpha naphthylamine            | lb. | 55    | —       | 60     |
| Aniline oil, drums extra       | lb. | 38    | —       | 39     |
| Aniline salts                  | lb. | 42    | —       | 43     |
| Anthracene, 80 per cent        | lb. | —     | Nominal | —      |
| Benzaldehyde (f. f. c.)        | lb. | 4 1/2 | —       | 4 50   |
| Benzidine, base                | lb. | 1 75  | —       | 1 85   |
| Benzidine, sulphate            | lb. | 1 40  | —       | 1 45   |
| Benzoic acid, U. S. P.         | lb. | 2 50  | —       | 2 75   |
| Benzoate of Soda, U. S. P.     | lb. | 2 25  | —       | 2 50   |
| Benzyl chloride                | lb. | 2 45  | —       | 2 50   |
| Beta naphthol benzoate         | lb. | 10 00 | —       | 12 00  |
| Beta naphthol, sublimed        | lb. | 75    | —       | 85     |
| Beta naphthylamine, sublimed   | lb. | 2 65  | —       | 20     |
| Dichlor benzol                 | lb. | 4 00  | —       | 4 50   |
| Diethylamine                   | lb. | 36    | —       | 38     |
| Dinitro benzol                 | lb. | 59    | —       | 41     |
| Dinitrochlorobenzol            | lb. | 55    | —       | 60     |
| Dinitrochlorobenzol            | lb. | 65    | —       | 75     |
| Dinitrophenol                  | lb. | 73    | —       | 75     |
| Dinitrophenylamine             | lb. | 1 00  | —       | 1 10   |
| Diphenylamine                  | lb. | 3 25  | —       | 3 50   |
| H-diol                         | lb. | 1 85  | —       | 2 05   |
| Metaphenylenediamine           | lb. | 09    | —       | 20 1/2 |
| Monochlorobenzol               | lb. | 09    | —       | 11     |
| Naphthalene, flakes            | lb. | 1 10  | —       | 1 22   |
| Naphthalene, balls             | lb. | 1 20  | —       | 1 30   |
| Naphthionic acid, crude        | lb. | 1 10  | —       | 1 10   |
| Naphthylamine-d sulphonic acid | lb. | 45    | —       | 50     |
| Nitro naphthalene              | lb. | 55    | —       | 60     |
| Nitro toluol                   | lb. | 65    | —       | 70 00  |
| Ortho-amidophenol              | lb. | 15    | —       | 20     |
| Ortho-chlorobenzol             | lb. | 1 00  | —       | 1 10   |
| Orthochloridine                | lb. | 75    | —       | 85     |
| Ortho-nitrotoluol              | lb. | 4 50  | —       | 50     |
| Para-amidophenol, base         | lb. | 4 25  | —       | 5 00   |
| Para-amidophenol, H. C. L.     | lb. | 15    | —       | 15     |
| Para-dichlorobenzol            | lb. | 1 75  | —       | 1 85   |
| Paranitraniline                | lb. | 1 50  | —       | 1 60   |
| Para-nitro-toluol              | lb. | 4 00  | —       | 4 50   |
| Paraphenylenediamine           | lb. | 2 25  | —       | 2 50   |
| Para-toluidine                 | lb. | 3 75  | —       | 4 00   |
| Phthalic acid anhydride        | lb. | 40    | —       | 44     |
| Phenol, U. S. P.               | lb. | 4 50  | —       | 5 00   |
| Resorcin, technical            | lb. | 7 00  | —       | 8 00   |
| Resorcin, pure                 | lb. | 85    | —       | 85     |
| Schizyl acid                   | lb. | 1 50  | —       | 2 00   |
| Sulphanilic acid, crude        | lb. | 31    | —       | 33     |
| T. d. line                     | lb. | 2 50  | —       | 3 00   |
| Toluol-mixture                 | lb. | 1 00  | —       | —      |

## Petroleum Oils

Crude and Refined

|                    |         |        |   |        |
|--------------------|---------|--------|---|--------|
| Petroleum, crude   | 100 lb. | 4 00   | — | —      |
| Petroleum, refined | 100 lb. | 2 80   | — | —      |
| Petroleum, refined | 100 lb. | 2 60   | — | —      |
| Petroleum, refined | 100 lb. | 2 68   | — | —      |
| Petroleum, refined | 100 lb. | 2 28   | — | —      |
| Petroleum, refined | 100 lb. | 2 42   | — | —      |
| Petroleum, refined | 100 lb. | 2 25   | — | —      |
| Petroleum, refined | 100 lb. | 2 25   | — | —      |
| Petroleum, refined | 100 lb. | 1 74   | — | 1 57   |
| Petroleum, refined | 100 lb. | 1 35   | — | —      |
| Petroleum, refined | 100 lb. | 1 90   | — | —      |
| Petroleum, refined | 100 lb. | 15     | — | —      |
| Petroleum, refined | 100 lb. | 10 1/2 | — | 15     |
| Petroleum, refined | 100 lb. | 07 1/2 | — | 10 1/2 |
| Petroleum, refined | 100 lb. | 1 65   | — | 2 35   |
| Petroleum, refined | 100 lb. | 1 65   | — | —      |

| Gasoline (Wholesale) |      |     |     |
|----------------------|------|-----|-----|
| New York, motor      | gal. | 244 | —   |
| Gas machine          | gal. | 41  | —   |
| 72-76 degrees        | gal. | 333 | 399 |
| 70-72 degrees        | gal. | 32  | 373 |
| 67-70 degrees        | gal. | 301 | 364 |
| Pittsburgh, motor    | gal. | 251 | —   |
| Chicago, motor       | gal. | 221 | 23  |
| Oklahoma, motor      | gal. | 211 | —   |
| San Francisco, motor | gal. | 201 | —   |

### Paraffine Waxes

|                             |     |     |     |
|-----------------------------|-----|-----|-----|
| Crude, 103 to 105 deg. m.pt | lb. | 081 | 09  |
| Crude, 118 to 120 deg. m.pt | lb. | 091 | 10  |
| Crude, 124 to 126 deg. m.pt | lb. | 10  | —   |
| Refined, 120 deg. m.pt      | lb. | 13  | —   |
| Refined, 128 deg. m.pt      | lb. | 14  | —   |
| Refined, 135 deg. m.pt      | lb. | 16  | 164 |
| Ozokerite, brown            | lb. | 75  | 80  |
| Ozokerite, green            | lb. | 85  | 90  |

### Lubricants

|                                             |      |    |    |
|---------------------------------------------|------|----|----|
| Black, reduced, 29 gravity, 25-30 cold test | gal. | 24 | 25 |
| Cylinder, light                             | gal. | 45 | 50 |
| Cylinder, dark                              | gal. | 39 | 43 |
| Paraffine, high viscosity                   | gal. | 40 | 41 |
| Paraffine, 0.903 sp. gr.                    | gal. | 36 | 38 |
| Paraffine, 0.885 sp. gr.                    | gal. | 26 | 28 |

### Flotation Oils

(Prices at New York unless otherwise stated)

|                                                     |      |    |    |
|-----------------------------------------------------|------|----|----|
| Pine oil, crude, f. n. b. Florida                   | gal. | 44 | —  |
| Pine oil, steam-distilled, sp. gr. 0.925-0.940      | gal. | 58 | 60 |
| Pine oil, destructively distilled                   | gal. | 58 | 60 |
| Pine-tar oil, sp. gr. 1.02-1.035                    | gal. | 35 | —  |
| Pine-tar oil, double refined, sp. gr. 0.965-0.990   | gal. | 37 | —  |
| Pine-tar oil, ref., light, sp. gr. 0.950, tank cars | gal. | 42 | —  |
| f.o.b. works                                        | gal. | 37 | —  |
| Pine-tar oil, ref., heavy, sp. gr. 1.025, tank cars | gal. | 28 | —  |
| f.o.b. works                                        | gal. | 32 | —  |
| Pine-tar oil, ref., tbin, sp. gr. 1.060-1.080       | gal. | 32 | —  |
| Turpentine, crude, sp. gr. 0.870-0.900              | gal. | 45 | —  |
| Hardwood oil, f.o.b. Michigan, sp. gr. 0.960-0.990  | gal. | 23 | —  |
| Hardwood oil, f.o.b. Michigan, sp. gr. 1.06-1.08    | gal. | 23 | —  |
| Wood creosote, ref., f.a.b. Florida                 | gal. | 31 | —  |

### Naval Stores

|                                          |              |       |       |
|------------------------------------------|--------------|-------|-------|
| Rosin A-E barrel                         | 280 lb.      | 15.25 | 15.60 |
| Rosin F-I                                | 280 lb.      | 15.60 | 16.00 |
| Rosin K-N                                | 280 lb.      | 16.00 | 16.00 |
| Rosin Q-W                                | 280 lb.      | 18.00 | 18.25 |
| Spirits of turpentine                    | gal.         | 71    | 73    |
| Wood turpentine, steam distilled         | gal.         | 62    | 65    |
| Wood turpentine, destructively distilled | gal.         | 58    | —     |
| Pitch                                    | bbl. 200 lb. | 8.00  | —     |
| Tar, kiln dried                          | 280 lb.      | 13.00 | 13.50 |
| Retort tar                               | 280 lb.      | 14.00 | 14.50 |
| Rosin oil, first run                     | gal.         | 80    | —     |
| Second run                               | gal.         | 83    | —     |
| Third run                                | gal.         | 88    | —     |
| Fourth run                               | gal.         | 98    | —     |

### Vegetable Oils

|                          |      |      |      |
|--------------------------|------|------|------|
| Castor oil               | lb.  | 33   | 34   |
| China wood oil           | lb.  | 24   | 26   |
| Cocunut oil              | lb.  | 16   | 21   |
| Corn oil                 | lb.  | 18   | —    |
| Coconutseed oil, crude   | lb.  | 20   | 22   |
| Linsed oil, raw, cars    | gal. | 1.81 | 1.86 |
| Palm                     | lb.  | 18   | 184  |
| Peanut oil, crude        | lb.  | 18   | 22   |
| Soya bean oil, Manchuria | lb.  | 17   | 183  |

### Glues

|                            |      |      |      |
|----------------------------|------|------|------|
| Extra white                | lb.  | 36   | 45   |
| Cabinet                    | lb.  | 31   | 40   |
| Brown foot stock           | lb.  | 22   | —    |
| Fish glue, 50-gal. barrels | gal. | 1.00 | 1.80 |

### Miscellaneous Materials

|                                     |         |         |       |
|-------------------------------------|---------|---------|-------|
| Barytes, roasted, white, foreign    | ton     | Nominal | —     |
| Barytes, roasted, white, domestic   | ton     | 33.00   | 36.00 |
| Beeswax, white, pure                | lb.     | 43      | 48    |
| Beeswax, unbleached                 | lb.     | 43      | 48    |
| Blanc fixe                          | lb.     | 051     | —     |
| Cassin                              | lb.     | 17      | 30    |
| Ceylon graphite                     | lb.     | 20      | 25    |
| Chalk, light, precipitated, English | lb.     | 041     | 06    |
| China clay, imported, lump          | ton     | 20.00   | 40.00 |
| China clay, domestic, lump          | ton     | 15.00   | 22.50 |
| Feldspar                            | ton     | 8.00    | 12.00 |
| Fluorspar, gravel, f.o.b. mine      | ton     | 28.00   | 40.00 |
| Fluorspar, washed, powdered         | ton     | 90.00   | —     |
| Fuller's earth, powdered            | lb. 100 | 1.50    | 2.00  |
| Japan                               | lb.     | 63      | —     |
| Mexican graphite                    | ton     | 60.00   | 75.00 |
| Madagascar graphite                 | lb.     | 10      | 15    |
| Orange shellac                      | lb.     | 72      | 80    |
| Pumice stone                        | lb.     | 08      | —     |
| Red lead, dry, carloads             | 100 lb. | 114     | 113   |
| Soapstone                           | ton     | 15.00   | 25.00 |
| Stearic acid, 120 deg. m.pt         | lb.     | 13      | 14    |
| Stearic acid, 140 deg. m.pt         | lb.     | 18      | 19    |
| Tale, American, white               | ton     | 20.00   | 40.00 |
| White lead, dry                     | lb.     | 091     | 103   |

### Refractories, Etc.

(F.O.B. Works)

|                                   |          |     |     |
|-----------------------------------|----------|-----|-----|
| Chrome brick                      | net ton  | 175 | —   |
| Chrome cement                     | net ton  | 75  | —   |
| Clay brick, first quality firelay | per 1000 | 50  | 55  |
| Clay brick, second quality        | per 1000 | 35  | 40  |
| Magnetite, raw                    | ton      | 30  | 35  |
| Magnetite, calcined, powdered     | ton      | 50  | 65  |
| Magnetite, dead burned            | net-ton  | 50  | 60  |
| Magnesian brick, 94-123           | ton      | 115 | 125 |
| Silica brick                      | per 1000 | 50  | 60  |

### Ferroalloys

|                                                  |     |      |      |
|--------------------------------------------------|-----|------|------|
| Ferrocabontitanium, 15-18 per cent, carloads     | ton | 200  | 250  |
| f.o.b. Niagara Falls, N. Y.                      | ton | 15   | 30   |
| Ferrocirium                                      | lb. | 30   | 40   |
| Ferrobromium, per lb. of Cr                      | ton | 250  | —    |
| Ferromanganese, domestic, 70 per cent basis      | ton | 250  | —    |
| Ferromanganese, English                          | ton | 75   | —    |
| Spiegeleisen (16-18%)                            | ton | 75   | —    |
| Ferromolybdenum, per lb. of Mo                   | lb. | 3.50 | 4.50 |
| Ferrosilicon, 75 per cent, f.o.b. N. Y.          | ton | 153  | 160  |
| Ferrosilicon, 50 per cent, contract              | ton | 7.35 | 2.40 |
| Ferrotungsten, 75-85 per cent, f.o.b. Pittsburgh | lb. | 2    | 50   |
| Ferrouranium, f.o.b. works, per lb. of U         | lb. | 75   | —    |
| Ferrovanadium, f.o.b. works                      | lb. | —    | —    |

### Ores and Semi-finished Products

|                                                       |      |      |        |
|-------------------------------------------------------|------|------|--------|
| Chrome ore, 45 per cent minimum, f.o.b. Cal. per unit | ton  | 1.50 | 1.55   |
| Chrome ore, 43 per cent and over, New York, per unit  | ton  | 1.40 | —      |
| Coke                                                  | ton  | 6    | 7.00   |
| Manganese ore, 48 per cent and over, per unit         | ton  | 1.20 | —      |
| Manganese ore, chemical                               | ton  | 80   | 100.00 |
| Molybdenite, per lb. of MoS <sub>2</sub>              | lb.  | 1.25 | 1.50   |
| Tungsten Scheelite, per unit of WO <sub>3</sub>       | ton  | 23   | —      |
| Tungsten, Wolframite, per unit of WO <sub>3</sub>     | ton  | 3.25 | 3.60   |
| Uranium oxide, 96%                                    | lb.  | 10   | —      |
| Vanadium pentoxide, 99%                               | lb.  | 10   | —      |
| Pyrites, foreign                                      | unit | 17   | —      |
| Pyrites, domestic                                     | unit | 28   | 301    |

### Plant Supplies

#### BUILDING MATERIALS

|                                        |         |       |        |
|----------------------------------------|---------|-------|--------|
| Common clay bricks                     | M       | 13.00 | 14.00  |
| Hollow tile, 4x12x12                   | M       | 60    | —      |
| Hollow tile, 12x12x12                  | M       | 120   | —      |
| Lime                                   | ton     | 16    | 50     |
| Portland cement                        | bbl.    | 2.59  | —      |
| Single glass (82-lb.), 10x26-16x24     | 21      | 00    | 27.00  |
| Double glass (164 lb.), 10x26-16x24    | 21      | 00    | 39.00  |
| Yellow pine lumber                     | M       | 39.00 | 45.00  |
| Fir lumber                             | M       | 38    | 53     |
| Hemlock                                | M       | 24    | 50     |
| Tarred felt (14-lb. sq.)               | ton     | 27    | —      |
| Roofing pitch                          | ton     | 27    | —      |
| Asphalt coated roofing (35-55-lb. sq.) | sq.     | 1.60  | 2.45   |
| Slate surfaced asphalt shingles        | sq.     | 25    | 5.50   |
| Corrugated galvanized iron             | ton     | 109   | 127.00 |
| Putty                                  | 100 lb. | 6.25  | —      |
| Red oxide (Ppte. Cuppers)              | 100 lb. | 15    | 20.00  |
| Native red oxide                       | 100 lb. | 3.25  | 8.00   |
| Red metallic paint                     | 100 lb. | 1.20  | 1.50   |
| White lead in oil                      | 100 lb. | 11.84 | 14.00  |
| Red lead in oil                        | 100 lb. | 12.28 | 14.50  |
| Zinc oxide (dry)                       | 100 lb. | 13    | 14.50  |
| Zinc oxide, leaded                     | 100 lb. | 9     | 10.00  |
| Yellow ochre                           | 100 lb. | 1.50  | 10.00  |
| Ultra marine blue                      | 100 lb. | 14    | 50.00  |
| Chrusian blue                          | 100 lb. | 135   | 150.00 |
| Chrusian green                         | 100 lb. | 40    | —      |
| Paris green                            | 100 lb. | 170   | 49.00  |
| Mineral black                          | 100 lb. | 1.75  | 2.25   |
| Powdered bone black                    | 100 lb. | 5.50  | 12.00  |
| Lampblack                              | 100 lb. | 15    | 45.00  |
| Gas carbon                             | 100 lb. | 16    | 25.00  |
| Mexican petroleum pitch                | 100 lb. | 1     | 2.00   |
| Gilsonite                              | 100 lb. | 2     | 2.50   |
| Coal tar pitch                         | 100 lb. | 60    | 1.25   |

#### STRUCTURAL IRON

|                                   |     |     |        |
|-----------------------------------|-----|-----|--------|
| Blue annealed sheet iron          | ton | 84  | 89.00  |
| Black sheet iron                  | ton | 96  | 104.00 |
| Galvanized iron                   | ton | 105 | 135.00 |
| Tern plate, 8-lb. coating         | ton | 150 | —      |
| Tern plate, 15-lb. coating        | ton | 127 | 50     |
| Tern plate, 25-lb. coating        | ton | 200 | —      |
| Tern plate, 40-lb. coating        | ton | 240 | —      |
| Tin plate, prime                  | ton | 155 | —      |
| Tank plates                       | ton | 60  | 65.00  |
| Beams, channels, angles, T's, Z's | ton | 65  | 70.00  |
| Rivets                            | ton | 88  | 92.00  |
| Steel pipe, 1 to 3-inch           | ton | 51  | —      |
| Bar iron and steel                | ton | 60  | 70.00  |
| Chain (link and coil)             | ton | 15  | —      |
| Nails, bolts, nuts, washers       | ton | 70  | 80.00  |
| Tool steels, special alloys       | ton | 300 | 500.00 |
| Bessemer pig iron                 | ton | 36  | —      |
| Bessemer steel                    | ton | 37  | —      |
| No. 2 foundry                     | ton | 37  | —      |
| Steel billets (4 x 4)             | ton | 47  | 50     |

#### POWER HOUSE SUPPLIES

|                              |     |     |      |
|------------------------------|-----|-----|------|
| Steam packing, rubber duck   | lb. | 99  | 1.10 |
| Asbestos, high pressure      | lb. | 176 | —    |
| Asbestos, wired              | lb. | 27  | —    |
| Asbestos, graphited braid    | lb. | 121 | —    |
| Asbestos, wick               | lb. | 75  | —    |
| Rubber, sheet                | lb. | 66  | —    |
| Cup grease                   | lb. | 07  | —    |
| Transmission grease          | lb. | 07  | —    |
| Axle grease                  | lb. | 044 | —    |
| Grease                       | lb. | 044 | —    |
| Cotton waste                 | lb. | 083 | 11   |
| Hose, underwriters, 2 1/2 in | ft. | 5   | —    |
| Hose, air, 1 in              | ft. | 50  | 60   |



# INDUSTRIAL

Financial, Construction and Manufacturers' News

## Construction and Operation

### Arizona

**CHLORIDE**—The Schuykill Mining Co. will build a 500-ton concentration plant at its works, to provide for increased capacity.

**DUNCAN**—The Duncan Mining & Milling Co. will build an 80-ton concentration plant.

**DUNCAN**—Harold C. E. Spencer and associates will build a cyanide plant on property five miles from Steeple Rock.

**HUMBOLDT**—The Silver Belt Consolidated Mining Co. will build a reduction plant having a capacity of 100-tons per day. Colonel J. B. Dudley, manager.

**KINGMAN**—The Emerald Isle Copper Co. will build a new leaching plant at its local properties.

**MAYER**—The Orizaba Mining Co. will abandon the old steam surface plant and install distillate or gasoline plant. J. K. Turner, engineer in charge.

**PHOENIX**—The Mount Turnbull Copper Co. is in the market for new machinery and equipment for development. C. B. Barnhard, manager.

**WICKENBURG**—The Octave Mining Co. will build a 250-ton stamp mill at its local properties.

### Arkansas

**ASHLAND**—The Dixie Graphite Co., Jefferson Bank Building, Birmingham, Ala., will build a 20-ton mill and develop the local graphite properties. J. R. Malaney, manager.

**BATESVILLE**—The National Mangane Co. recently incorporated with a capital of \$100,000 will build a washing plant and plans the immediate installation of the necessary equipment for the development of approximately 230 acres of manganese properties. C. A. Enoche, president, and J. L. Elliott, vice-president.

**CUSHMAN**—The Enley Mining Co. will build a washing plant and is in the market for a log washer, jigs, belts, shafting, pulleys and mine equipment. Estimated cost, \$10,000. Clarence Edge, superintendent.

**DODD CITY**—The Salina Mining Co. will build a mill and is in the market for crushing and concentration machinery and mine equipment. Estimated cost, \$25,000. E. D. McGuire, superintendent.

**RUSH**—The Ozark Mining & Milling Co., Yellville, will build a 100-ton mill for the handling of zinc and lead ores. E. E. Scofield, manager.

### California

**MARE ISLAND**—The Bureau of Yards & Docks, Navy Department, Washington, D. C., has awarded the contract for the construction of an oxy-acetylene plant here, to James L. McLaughlin, 234 Kearney St., San Francisco. Estimated cost, \$36,357. Noted Oct. 15.

**REDDING**—The Bully Hill Mining Co. will build a 150-ton flotation plant at its mine. Estimated cost, \$75,000.

### Colorado

**GARFIELD**—The Garfield Mining Co. will build a 50-ton mill at its properties here.

**SUNSHINE**—The Nil Desperandum Mines Co., Box 298, Boulder, will build an oil flotation plant to have a capacity of not less than 50 tons. Estimated cost, \$10,000. M. S. Brandt, president and general manager.

### Connecticut

**NEWINGTON**—Thomas F. Garvan & Co., Church St., Burnside, (Hartford P. O.), will rebuild its paper plant recently destroyed by fire entailing a loss of \$30,000.

## District of Columbia

**WASHINGTON**—The Bureau of Fisheries, Department of Commerce, received bids for the construction of a laboratory building at 7th and B Sts., from Boyle-Robertson Construction Co., 601 Evans Building, \$46,252; James L. Parsons, Jr., 332 Southern Building, \$48,462; A. C. Morse Construction Co., 916 New York Ave., \$48,110. Noted Nov. 30.

## Florida

**KEY WEST**—The Bureau of Yards & Docks, Navy Department, Washington, D. C., plans to build a photo-laboratory here. Specification No. 3632. Estimated cost, \$7,000.

**TAMPA**—The Texas Co., 204 Gulf Bldg., Houston, has awarded the contract for the construction of an oil distributing plant, to G. A. Miller, 23 Petteway Blvd. Estimated cost, \$150,000.

**VERO**—The McVey Lindsey Co., Jacksonville, will build a syrup mill to have a grinding capacity of 60 tons per day. Estimated cost, \$15,000.

## Idaho

**BOISE**—The Sewer Department of the City Council is having studies made for the construction of a sewage disposal plant. C. C. Stevenson, engineer.

## Illinois

**CHICAGO**—The Chicago Starch Co., Throop and 27th Sts., has awarded the contract for the construction of a three story, 28 x 45 ft. factory, to Cameron Bros., 115 South Leavitt St.

**CHICAGO**—The Johns-Manville Co., Mayville, N. J., has purchased 225 acres of land near the town of Chicago, north of Chicago, and will build a plant for the manufacture of asbestos and magnesite. Estimated cost, \$5,000,000.

**CHICAGO**—The La Salle Steel Co., 2243 South La Salle St., has awarded the contract for the construction of two factory additions on 12th St. and 54th Ave., to Brolne & Nolan, 8 South Dearborn St. Estimated cost, \$18,000.

**CHICAGO**—D. A. Stewart & Co., 352 East Illinois St., will build a one story, 100 x 100 ft. factory on 31st St. and Kedzie Ave., for the manufacture of lubricating oil. Estimated cost, \$25,000. R. T. Newberry, 108 South La Salle St., architect.

**CHICAGO**—Swift & Co., U. S. Yards, will build an addition to its soap factory. Estimated cost, \$75,000. C. H. Kane, c/o owner, architect.

**CHICAGO**—Swift & Co., U. S. Yards, has awarded the contract for the construction of a three story, 200 x 300 ft. fertilizer plant to the Wieboldt Construction Co., 1524 West Van Buren St. Estimated cost, \$550,000.

**CHICAGO**—Wilson & Co., U. S. Yards, will build a three story, 33 x 129 ft. animal oil refinery building. Estimated cost, \$37,000. C. P. Barrett, c/o owner, architect.

**FAYVILLE**—The Actna Explosives Co., 120 Broadway, New York City, N. Y., will build an addition to its manufacturing plant here.

**GREAT LAKES**—The Bureau of Yards & Docks, Navy Department, Washington, D. C., has awarded the contract for the construction of an addition to the water distribution system, to Daniel Hardin, 3139 Indiana Ave., Chicago. Estimated cost, \$125,000.

## Kentucky

**IRVINE**—The Mac-Lan Oil Co., Winchester, organized with J. W. McCulloch, Pres., Owensboro and J. H. McClurg, gen. mgr., Winchester, plans to develop oil land here.

**PADUCAH**—The Wallace Fluoropar Co., recently organized, will develop over 100 acres of local fluoropar properties and is in the market for machinery and equipment. C. P. Barrett, c/o owner, about 150 tons per day. N. R. Barbes, president.

## Maryland

**INDIAN HEAD**—The Bureau of Yards & Docks, Navy Department, Washington, D. C., has awarded the contract for the construction of improvements to powder factory here, to Scott Brothers, Rome, N. Y. Estimated cost, \$38,605.

## Massachusetts

**BOSTON**—The Air Reduction Co., 120 Broadway, New York City, N. Y., has awarded the contract for the construction of a one story, 60 x 100 ft. plant, to the Austin Co., 217 Broadway, New York City, N. Y. Estimated cost, \$100,000.

**BOSTON**—The General Bond & Share Co., 30 Kilby St., capitalized at \$10,000, has taken over the plant of the Chapin Chemical Co., and will establish a large refinery on the property in the Seales Lake potash district.

**NORTH TRURO**—The East Harbor Fertilizer Co., 233 Bridge St., Springfield, will build a two story, 70 x 70 ft. fertilizer plant. Estimated cost, \$30,000.

**SHELBURNE FALLS**—The Mayhew Steel Products Co., 295 Broadway, New York City, N. Y., has awarded the contract for the construction of a one story, 60 x 100 ft. plant, to the Austin Co., 217 Broadway, New York City, N. Y. Estimated cost, \$115,000.

## Michigan

**DETROIT**—The Detroit Copper & Brass Rolling Mills, Clark Ave., has awarded the contract for the construction of an addition to its plant, to A. A. Albrecht, Penobscot Bldg. Estimated cost, \$400,000.

**DETROIT**—The Michigan Smelting and Refining Co., 1685 Joseph Campau Ave., will build a one story, steel cupola building, Albert Kahn, Marquette Building, architect.

**WYANDOTTE**—The city will construct a filter plant having a daily capacity of 6,000,000 gallons, composed of 6 filter units, 2 1/2 x 24 ft. of 1,000,000 gallons capacity each; 40 x 65 ft. and 37 x 73 ft. brick and steel filter house and head house; 2 coagulation basins of 64 x 34 ft. each; filtered water reservoir having capacity of 850,000 gallons; usual equipment of hydraulic valves and machinery; 100 x 100 ft. brick addition to pumping station. R. W. Pratt, 232 Jefferson Ave., Detroit, engineer.

## Minnesota

**WORTHINGTON**—The Commissioners of Nobles County have awarded the contract for the construction of a filter plant for the Southwestern Minnesota Sanitarium, to W. Danforth, Germania Life Bldg., St. Paul. Estimated cost, \$13,660.

## Missouri

**ST. LOUIS**—The Mallinckrodt Chemical Works, 2nd and Market Sts., St. Louis, has awarded the contract for the construction of a three story, 70 x 100 ft. plant for the manufacture of ether, to the A. H. Haeseler Building & Contracting Co., Wainwright Building. Estimated cost, \$65,000.

## Montana

**BASIN**—The Montana Consolidated Copper Co., 51 Wall St., New York City, N. Y., will remodel concentrator here for the treatment of mine ore. Properties in the market for rolls, jigs, tables, shafting, belting, motors, pumps, and possibly M. S. flotation machines, etc. Total estimated cost, \$200,000. E. P. J. Burgess, president.

## Nebraska

**OMAHA**—The city will build disposal plant for the Saddle Creek District. J. A. Bruce, city engineer.

## Nevada

**ELY**—The Shepherd Mining Co., operating tungsten properties in the White Pine Section, will build a 15-ton mill.

**LAS VEGAS**—T. Thorkildsen, Trade & Savings Building, Los Angeles, Cal., operating local manganese properties here, will double the capacity of plant which now averages about 200 tons per day.

## New Jersey

**NEWARK**—The F. W. De Voe & C. T. Reynolds Co., Inc., 223 New Jersey Railroad Ave., will build a 105 x 150 ft. plant for the manufacture of paper.

## New York

**BROOKLYN**—The George Washington Refining Co., 147 41st St., will build a

one story, 200 x 400 ft. refining plant. Austin Co., 217 Broadway, New York City, engineer R.

**BUFFALO**—The Donner Steel Co., Abbott Rd., will build three one story additions to its plant and a new addition to its plate mill. Estimated cost, \$27,000.

**DUNKIRK**—The Atlas Crucible Steel Co., Howard Ave., will build a one story addition to its plant.

**LONG ISLAND CITY**—The West Disintegrating Co., 411 5th Ave., New York City, has awarded the contract for the construction of a two story, 75 x 125 ft. factory on Bern St. and Jackson Ave., to Walter Bond, 12 Hallett St. Estimated cost, \$25,000.

**NEW YORK**—F. L. Dowling, president of Manhattan Borough, received bids Nov. 26 for furnishing and delivering liquid chlorine, from the Electro Bleach & Gas Co., 13 East 41st St., \$6120; A. Hoffman & Co., Providence, R. I., \$6900; furnishing and delivering sulphate of copper, from J. A. Miller, Grice, 39 Cordant St., \$2900; J. A. Miller, 4 West 34th St., \$2907; Knickerbocker Supply Co., 149 Church St., \$3045.

**POUGHKEEPSIE**—The Palline Aniline & Chemical Co. will build an addition to its plant for the manufacture of ferro-alloys. Estimated cost, \$40,000.

**MONROE**—The Bureau of Yards and Docks, Navy Department, Washington, D. C., will build a group of radio buildings here. Estimated cost, \$250,000.

## Ohio

**CARROLLTON**—The Robinson Clay Products Co. will build an addition to its plant.

**CASTALIA**—James D. Rhodes, Keystone Building, Pittsburgh, Penna., has been authorized by Judge Charles F. Orr, in the United States district court, to enter into an agreement with the Castalia Portland Cement Co. to experiment with the process by which he can wash iron dust from the kilns. It is understood that Mr. Rhodes, at his own expense, will erect a large experimental plant, adjoining the plant at Castalia. If the process is found to be of commercial value a \$1,000,000 plant will be erected and the process may be adopted in every cement-producing plant in the United States.

**CLEVELAND**—The Aluminum Castings Co., 2600 Harvard Ave., has awarded the contract for the construction of a one story, 50 x 200 ft. steel and concrete smelting finishing building, to the J. H. Chaney Co., Hippodrome Building. Estimated cost, \$100,000 and \$150,000 respectively.

**CLEVELAND**—The Ideal Bronze Co., 1265 East 53th St., will build a brick and concrete factory. Estimated cost, \$100,000.

**CLEVELAND**—The Kokomar Co., 455 Leader-News Building, will remodel its former brewery into a food manufacturing plant, where condensed butter, margarine, cereal, etc., will be made. The company is in the market for about \$100,000 worth of machinery.

**CLEVELAND**—The Reflex Ignition Co., 1705 Payne Ave., will build a two story, 50 x 75 ft. brick and concrete factory on West 106th St. Estimated cost, \$25,000.

**CLEVELAND**—The United States Copper Co., Guardian Bldg., will build a steel and concrete corner and brass mill. Estimated cost, \$100,000.

**RAVENNA**—The Oak Rubber Co. will soon award the contract for the construction of a three story concrete and steel factory. Estimated cost, \$100,000. Noted Nov. 30.

**SANDESKY**—The Libby Glass Co., South Hancock St., will rebuild its plant recently destroyed by fire.

## Pennsylvania

**BETHLEHEM**—The Air Reduction Co., 120 Broadway, New York City, N. Y., has awarded the contract for the construction of a three story, 120 x 200 ft. steel and concrete oxygen plant, to James Mitchell, Inc., 76 Montgomery St., Jersey City, N. J. Estimated cost, \$150,000.

**PHILADELPHIA**—The Ralfe Tannery will build additions to its plant.

**MAHANAY CITY**—The Hercules Powder Co., Du Pont Building, Wilmington, Del., will build a one story addition to its local plant.

## Tennessee

**COLUMBIA**—J. Ogden Armour Fertilizer Co. (branch of Armour & Co., Union Stock Yards, Chicago, Ill.), will build a

phosphate plant near the Century Mines and is in the market for phosphate dryers, washers and grinding plant, for the manufacture of fertilizer material. Total estimated cost, \$550,000.

## Texas

**FORT WORTH**—The Purety Serum Co., incorporated by John Kennedy, vice-president, and J. N. Huff, secretary, with \$150,000 capital has purchased a group of factory buildings here and will remodel same to manufacture serums and vaccines.

**GALENA**—The Petroleum Refining Co. will build additional units at its oil refinery.

**HOUSTON**—The Crown Oil Co. will build an oil refinery on Houston Ship Channel. Estimated cost between \$500,000 and \$1,000,000.

**HOUSTON**—A. E. Fitkin & Co., 141 Broadway, New York City, N. Y., has purchased a site on San Jacinto Bay and will establish an oil refinery for the manufacture of lubricants, to have an initial capacity of 330 barrels of crude oil daily.

**MARFA**—The Capote Nitrate Co., San Antonio, recently organized with a capital of \$100,000, will establish a plant for the production of nitrate of potassium, sodium nitrate, and allied products near here. G. C. Simpson is interested.

**WICHITA FALLS**—The American Refining Co. will build an oil refinery.

## Utah

**PROVO**—The General Reduction and Chemical Co., 23 West 2nd St., Salt Lake City, will build a plant here.

## Virginia

**NORFOLK**—The city will build an addition to its filtration plant, to consist of two concrete filter units. Estimated cost, \$70,000. W. H. Taylor, city manager. Noted Nov. 30.

## Washington

**NORTHPORT**—The Northport Smelting & Refining Co. will build a dressing plant. Estimated cost, \$50,000.

**SPOKANE**—The stockholders of the Loon Lake Rubber Co., Columbia Building, voted a bond issue of \$90,000 for the construction of a mill at its property in Stevens County. Frederick Dewart, National Bank Building, attorney.

**SPOKANE**—The Nabob Consolidated will build a concentrator, having a capacity of 150 tons per day at the old Nabob mill. It will be reached by the tram moved up from the Stewart property. Address William Beaudry.

## West Virginia

**FAIRMONT**—The Domestic Coke Corp., 1208 Engineers' Building, Cleveland, Ohio, has awarded the contract for the construction of a by-products coke plant, to H. Koppers Co., Union Arcade Building, Pittsburgh, Penn. Estimated cost, \$3,000,000.

## Wisconsin

**DEPERE**—G. Diamond, 2109 Walnut St., Milwaukee, has purchased a 24,000 sq. ft. site here and will build a two story factory for the manufacture of paper boxes and cardboard.

**SHEBOYGAN**—The city will build a sewage disposal plant.

**WEST ALLIS**—The First-O-Lite Co., 619 Trowbridge St., will rebuild its acetone production plant, recently destroyed by an explosion entailing a loss of \$10,000.

## Wyoming

**CASPER**—The Northland Refining Co. will build six 1000 barrel stills at its local refinery.

## Alberta

**EDMONTON**—The Northland Oil Syndicate will make improvements to its oil plant. Estimated cost, \$50,000. A. Schmidt, Box 301, Edmonton, is interested.

**LETHBRIDGE**—The Imperial Oil Co., Sarnia, Ont., will build an addition to its plant. Estimated cost, \$65,000.

## British Columbia

**GRAND FORKS**—The Consolidated Mining & Smelting Co. will build a reduction plant having a capacity of 100 tons per day at the railroad terminal. Estimated cost, \$37,000. Dan Matheson, superintendent.

**JEDWAY**—The Producers' Mines, Ltd., will install a compressor plant near here. Frank Buckingham, superintendent.

**KAMLOOPS**—W. H. Aldridge, 14 Wall St., New York City, N. Y., will build a reduction plant and a two drill compressor plant, operated by gasoline. W. R. May, Vancouver Building, Vancouver, superintendent.

**STUMP LAKE**—The Donohoe Mines, Ltd., Pioneer Building, Seattle, Washington, will build a concentration plant here. F. M. Hawkes, superintendent.

## Ontario

**ARNTRIOR**—Huyck & Sons will build an addition to its plant for the manufacture of paper. Estimated cost, \$20,000.

**BELLELEVILLE**—The Belleville Rubber Co., Ltd., has been incorporated by Wilson S. Morden, 12 King St., Toronto, Ernest W. McNeill, 350 Spadina Road, Toronto, and others with \$1,000,000 capital stock, to manufacture rubber, rubber goods, etc.

**CHATHAM**—The Waterworks Commission will install a laboratory to enable it to make daily bacteriological tests on the city water.

**LONDON**—The Société Liquide Air Montreal, Que., will build a brick factory and is in the market for machinery for acetylene work. Estimated cost, \$75,000.

**TORONTO**—The Alloy Steel Works, Ltd., 400 Front St., will build a two story addition to its plant.

**TORONTO**—The Canada Metal Co., Fraser Ave., will build a one story brick addition to its plant. Estimated cost, \$15,000.

**TORONTO**—The Gutta Percha & Rubber Co., 130 O'Hara Ave., will build an addition to its plant. Estimated cost, \$5000.

**TORONTO**—The Matthews Packing Co., Bathurst St., will build a new fertilizer plant. Estimated cost, \$55,000.

**TORONTO**—The city water commission, has recommended to the City Council that a Wallace and Tiernan liquid chlorine plant be installed at Toronto Island. He states that a considerable saving of sulphate of alumina will be thus effected at the filtration plant. Estimated cost, \$3000.

**WINDSOR**—The city plans an election January 1, to vote on a bond issue of \$250,000 for the construction of a sand lagoon having a daily capacity of 12,000,000 gallons. R. W. Pratt, Hippodrome Building, Cleveland, Ohio, engineer.

## Quebec

**OUTREMONT**—McArthur Irwin, Ltd., 20 St. Paul St., W. Montreal, will build a plant for the manufacture of paints, oils, and chemicals. Estimated cost, \$60,000.

**THREE RIVERS**—The Canada Iron Foundries, Ltd., St. Maurice St., has awarded the contract for the construction of a one story brick extension to its plant, to Nabors, Magre & Arseneault. Estimated cost, \$75,000.

## New Publications

**BUREAU OF STANDARDS TECHNOLOGICAL PAPER NO. 110** entitled "Influence of Quality of Gas and Other Factors on the Efficiency of Gas-Mantle Lamps," by R. S. McBride, W. G. Dunkley, E. C. Crittenden and A. H. Taylor.

**NORTH CAROLINA GEOLOGICAL AND ECONOMIC SURVEY, ECONOMIC PAPER NO. 48**, "Forest Fires in North Carolina, During 1915, 1916 and 1917 and Present Status of Forest Fire Prevention in North Carolina," by J. S. Holmes.

**UNITED STATES NATIONAL MUSEUM, Bulletin 192, Part 5**, of the Mineral Industries of the United States entitled "Powder: Its Significance and Needs" by Chester G. Gilbert and Joseph E. Pogue.

**POTASH AS A BY-PRODUCT OF THE CEMENT INDUSTRY**, by Richard K. Meade, Baltimore, Md. This booklet is a reprint of articles appearing in "Rock Products" in the July 17 and 31 and Aug. 14 and 28th issues, 1918.

**NEW BUREAU OF MINES PUBLICATIONS: Bulletin 160: Rock Quarries for Cement Manufacture**, by Oliver Bowles. Bulletin 171: Melting Brass in a Rocking Electric Furnace, by H. W. Gillett and A. E. Rhodes. War Minerals Investigations Series No. 4 dated Nov. 1918. Note on The National Importance of Allocating Low-ash Coke to the Manganese-Alloy Furnaces. By P. H. Royster.













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